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Contents for January 1, 1917

Nineteen Hundred and Seventeen

The enormous prosperity which the chemical and metallurgical industries have enjoyed during the past year, cannot last unimpaired forever; it has been an integral part of the general industrial prosperity of this country and closely related to the international trade conditions brought about by the European war. When the war stops, there will come in this country, too, a period of industrial readjustments. Are the chemical and metallurgical industries as living organisms prepared for this radical change that must come some day? While in an economic as in a gastronomic sense it is bad to have "too much of a good thing," it can be said that in spite of their prosperity the chemical and metallurgical industries in the vast majority are in a thoroughly sound condition, that is in all essentials. As the many reviews of different industries throughout this issue will show, much has been accomplished in enlarging old and creating new establishments and industries. It cannot be expected that all of these will last. But in the larger new undertakings, at least, foresight into the conditions after the war has not been absent. What is needed now more than anything else is a sane, sensible legislative policy in Washington. There are some very discouraging signs—the pork barrel business, the coward stupidity with which the Niagara power problem is being handled, the attempt of penalizing publications of nation-wide importance for the benefit of local papers by new second-class matter rates. But there are hopeful signs, too; most shining perhaps the Tariff Commission soon to be appointed. And we may hope that, as so often before, the common sense and fairness of the American people will win out in spite of the politicians and find the right solution.

"So Nice and Poor"

She lives in a house in New York that is as big as a church and the annual tuition paid for her as a day scholar at school is a sum on which many a self-respecting family has been brought up.

She wanted to spend Sunday in the country with the Shorts. Now the Shorts are people of quality and merit, but not of circumstance. "Are you so fond of Hilda?" asked her father. "Oh," replied the daughter, with that integrity of youth which we have forgotten, "I like her well enough." "That is not convincing," he continued, "why do you want to go?" "Because the Shorts are so nice and poor," answered the girl.

There we have it. They are nice and poor. There are no butlers and second men, there is no governess or anything to disturb the spirit or hinder the flow of soul. The house is honest in its business of providing shelter and food for a family without a lot of uninter-

ested strangers about, earning their living by standing in everybody's way. A house where we can enter the kitchen and talk to the cook; where we can see what is going on. Jealousy and hatred and bickerings are things one can smell if he is young enough, and these things befoul the air of nearly every very big house. In a little one among those that are nice and poor there is no room for such things. A reasonable person, unspoiled by years and conventions, holds to the pursuit of happiness as is duly set forth in the Declaration of Independence. Some of us have forgotten it, and we take occasion, now that Christmas tide and New Year's Day are at hand, to preach a little sermon on the subject.

Few of us have the equipment of heart to fill a large house. We can fill it with vanity and fill it with show. The first is a gift that most of us can find by an inward glance, and the second is easily purchased. We can fill it with rules and with obedience, if we hold to the letter, but it is very hard to fill it with ourselves and have it a pleasant abode withal.

Most of us that are old enough can remember a house or so that was joyous that seemed big and was full of a great big man who was its master, but nowaways, if we look over those that are left, they seem surprisingly small. The modern big house is a palace, built in imitation of establishments designed for kings and queens, and these are next to impossible to fill with the spirit of good-fellowship.

We wish health and prosperity to all our readers. And then we wish them something more, something better and more valuable: that with prosperity may come such growth of understanding and sympathy as makes for the general welfare. There are side chains of antibodies that accompany every experience of life, and one of these is the very devil of vapid pomp, that jumps upon our backs as soon as the money comes rolling in. It spoils us and makes us little in the measure that we think ourselves big. We wish our readers deliverance of this evil and, in all prosperity, that quality of spirit which renders them "nice and poor."

Flotation Practice in 1916

The full effect of the application of flotation to various milling problems in North America has been felt during the past year. The call for increased production of all the metals was answered in some cases by installing flotation plants. In fact, we doubt very much if metal prices could have been held down as low as they have been if it had not been for the use of flotation in concentrating certain ores.

Practically every large copper company which is milling ores is now using flotation and thereby gaining simplicity and compactness in the mill flow sheets and also increasing the extractions over what was formerly possible. The simplifying and condensing of the mills has allowed greater capacities in the same floor space. By merely increasing grinding capacity through the switch from pebbles to iron balls, many companies are now producing almost twice the amount of copper formerly concentrated, and often at a considerably lower unit cost.

One interesting point which has come up has been the actual testing out of large and efficiently operated mills where flotation was used as the major process. The Minerals Separation Company in years past has tried to get its clients to use flotation for the concentration of the ore with as little auxiliary concentrating apparatus as possible. They have claimed that the greater simplicity of operation gained by reducing the ore directly to the size necessary for flotation is worth the trouble. Of course, ores with more than one mineral, like zinc-lead ores, are exempt from this dictum. Minerals Separation was naturally interested in seeing as large a tonnage of ore treated by flotation as possible and other engineers have wanted to know whether this was the right flow sheet or not. The operation of the big new concentrator at Inspiration has done much toward answering this question, although there is still some doubt about just what it does mean. At Inspiration they find that they still have to operate tables on the flotation tailing, making 10 per cent of their total extraction by this method. Of course, the grinding leaves a considerable proportion of sands and there is also some "oxide" copper caught on the tables which would otherwise escape. As soon as the leaching of the flotation tailing is in operation, the total recovery on the tables could easily be much less. Tables do not cost much to operate and it is a question whether slightly finer grinding would cost more than the operation of these tables. So the Minerals Separation engineers were very nearly right and it may be that they will yet be fully justified. These considerations apply more nearly to large mills like the one at Inspiration than to smaller ones such as that of the Engels Copper Co., in California, where flotation is the only concentration process used.

It was thought for a time that flotation would be a serious competitor to cyanidation, when applied to gold and silver ores, but the general consensus of opinion now seems to be that it will be applied only to ores that are difficult to cyanide and that usually it proves to be a most useful adjunct to cyanidation. If the ore deposit being treated happens to be near a smelter, it is probable that the flotation concentrates will be smelted rather than reduced to bullion by the cyanide process. Otherwise flotation will be used on difficult ores to reduce the ore to a concentrated form, so that very careful cyanidation of a small bulk by highly specialized methods, such as that used in the "high grade" mills at Cobalt, may be practised. The advantages of shipping bullion from distant districts are such that cyanidation will probably not be abandoned unless methods of melting down flotation concentrate, such as those used for cyanide precipitate, can be invented.

With the ability to handle slimes, a return to machinery giving a maximum grinding effect for a given amount of power is being made. Only on ores that are incapable of flotation is the production of slimes still a curse. Crushing of ores for magnetic or electrostatic concentration must still take place in machinery that makes a minimum of slimes, and in tungsten concen-

tration the production of slimes and dust is also usually to be avoided, although one party claims to be able to float scheelite. It is probable that flotation methods will finally be developed to supplant such processes and on that account we look for magnetic concentration and electrostatic separation to be placed in more restricted fields than ever. In fact, with the zinc-iron mixtures, it is probable that the "magnetic" roast will be slightly prolonged to insure alteration of the pyrite, and that the material will then be ground and treated by flotation. This allows of higher extractions of the zinc and of the treatment of more disseminated ores. We are surprised that the companies treating the more complex sulphides in the Western mining states have not adopted this method of separation. For some time there has been known to be available the Horwood process which gives the finely ground ore a flash roast enough to alter the surfaces of the pyrite particles while sphalerite is unaltered, but the roasting of fairly coarsely ground ore, to alter the pyrite deeply enough to allow fine grinding in water just before flotation, removes the objections that were raised to Horwood's process, which required a dry but finely ground feed to the roasters, a thing usually difficult to obtain. Further, as far as we know, it is not a patented process.

Grinding machinery is not the only mill machinery to be altered. Flotation machinery itself has seen a remarkable development during the year and the announcement of the Inspiration machine, the Cole-Bergman, the Kraut & Kohlberg, the Jones-Belmont, the Parral, etc., have appeared and a new type of Janney machine with "air baskets" in the spitzkasten has also made its appearance. Some of these machines have not been designed merely to avoid payment of patent royalties, as some of them quite frankly are, but there is a real advance in the art and some of the mechanical improvements are quote ingenious. The saving in power which some of them allow is considerable and the limit has not been reached. The question of saving power is now quite commonly considered, and it is recognized that where the flotation oils can be added to the ball mills before the pulp reaches flotation, the oil is not only well distributed but increased extractions are sometime possible. Where the oils are added ahead of the ball mills there is very little "agitation" of the pulp necessary during flotation and pneumatic cells of one design or another are probably the logical machines to use under these conditions. Would that patent litigation could cease and the real truth about the benefits of different systems of flotation be made available!

The year has seen the installation of several "sulphidizing" and flotation plants for the treatment of oxidized ores of base metals. At the time of writing oxidized copper is being floated by means of hydrogen sulphide sulphidizing at the Magma mill in Arizona. while lead carbonate ore is being floated by the use of sodium sulphide as a sulphidizer at the Prince Consolidated mill in Nevada. A number of other companies have experimental mills under way. The importance of the treatment of oxidized ores is almost impossible to estimate. The use of small units on such ores will allow of the treatment of the oxidized ores on the outcrops of many properties through Nevada, Utah, Arizona, New Mexico, Colorado, Idaho, Montana, Washington, Oregon and California. In these states are thousands of prospects whose outcrop ores are often too low-grade to ship. Flotation of the oxidized ores will allow of their being developed at a profit and besides a flotation mill will treat the sulphide ore which is reached with depth. The further development of processes to treat these ores is hence anxiously awaited.

The flotation process has come to stay. Already it is being used in the treatment of well nigh 150,000 tons of ore daily in North America, and there is believed to be enough new work on foot so that the tonnage will be doubled in about five years.

At the beginning of 1916 the situation in obtaining a supply of flotation oils was somewhat acute. While it is still hard to get all the oils wanted, many of the mills have now found supplies of material with which they can operate, although the most desired materials are sometimes hard to get. Coal tar and creosote from practically all of the intermountain gas plants has been contracted for and much material from the Middle West is now being used. Sage brush oil has been found to be an excellent flotation oil, and a movement is now on foot to distill sage oil from some of the larger "forests" of Idaho, Utah and Nevada.

The Year 1916 in Copper

The year 1916 was one of unprecedented prosperity for the copper producers. The price of the metal increased from 18 cents per pound at the close of the previous year to 33 cents at the close of the past year. So great is the demand for copper that it is estimated that nearly all of the production for the first half of 1917 has been sold at prices around 30 cents per pound.

It seems likely that this condition will continue for the duration of the war in Europe. The end of hostilities will probably cause a decided diminution in the demand for copper; at least until such time as a readjustment can be effected and the reconstruction period is actively under way. Although the shipments of copper from this country to Europe have been larger than ever before, England and France have both been forced to cut heavily into accumulated stocks.

Stimulated by the extremely high prices the copper companies have made every effort to increase their output, and have in most cases succeeded in adding anywhere from 30 to 50 per cent to their production. The Anaconda Copper Mining Company produced about 340,000,000 lb. in 1916 as compared with 235,000,000 in 1915. The Utah Copper Company produced about 225,000,000 lb. in 1916 as against 148,000,000 in 1915. Similar increases have been made by Chino, Ray Consolidated, Granby, and others.

Inspiration has been brought into the producing stage to such good effect that its average production per month for the year was in excess of 10,000,000 lb., and at the close of the year it was producing about 11,500,000 lb. per month. This company has probably

the most modern and up-to-date mining and milling plant in existence. The automatic hoist is a source of wonder to everyone who has seen it. It is astonishing with what smoothness and ease the enormous output of 18,000 tons per day is raised by this equipment. The Inspiration concentrator was the first large copper plant to be put entirely on a flotation basis, and it has been an unqualified success. While tables are in use they merely serve to catch the few coarse grains of mineral which may have dropped back in the flotation machines. Large drag-belt classifiers are used between the flotation machines and the tables for the purpose of desliming the feed to the tables. Experiments, however, have demonstrated that these classifiers are hardly needed, as the work which the tables are called upon to perform would be done equally well without them. It seems to be generally conceded that the scheme adopted by Inspiration of following the flotation machines with tables instead of preceding them is the better practice where the ores undergoing treatment contain the copper minerals in a finely disseminated form and where the concentration ratio is large. The flotation machines catch the fine mineral equally as well in the presence or absence of coarser mineral, and in view of the fact that they operate on a denser pulp than the tables, the arrangement adopted at Inspiration eliminates a lot of dewatering apparatus which would otherwise be needed.

At Anaconda conditions are widely different; here there is an ore containing about four parts of iron for every one part of copper, with the result that the concentration ratio is only three into one. Moreover, the mineral is so coarse that over two-thirds of it can readily be removed after grinding to 2 mm. The coarser table concentrates are so much easier to handle in the smelter and the dust losses are so much less that it would be obviously unwise to grind everything to flotation size before commencing concentration.

The remodeling at Anaconda was completed during the year, and the entire reduction works are now operating on the new basis. The plant has produced in excess of 27,000,000 lb. of copper per month for several months. The normal monthly output is between 25,000,000 and 26,000,000 lb.

The coal-dust fired reverberatories and the 20-ft. Great Falls converters have proved an unqualified success, although from last accounts it appears that the prestige of the latter is likely to be somewhat diminished by the new Smith-Pierce converter at El Paso, which is of exceptionally large size and improved design.

The No. 2 roaster plant, which contains twenty-eight 25-ft. Anaconda-Wedge furnaces, has proved a complete success, and the furnaces are roasting concentrates containing 33 per cent sulphur down to 7 per cent at the rate of 150 tons per day each.

A problem of continually increasing importance to the copper and lead smelter is the prevention of damage to the surrounding country by means of dust and sulphur dioxide. Very little has been done with regard to the latter except so far as this can be accomplished by dilution of the gases. The precipitation of dust is being effected in several places by means of the Cottrell treater, which under favorable conditions is capable of producing excellent results. At the new smelter of the International Smelting Company at Miami, which treats the concentrates from both the Inspiration and Miami concentrators, Cottrell treaters are used at both roaster and converter plants. At the former the treaters are mounted directly over the furnaces and no dust chamber is used. The installation has been very successful, and the perfection with which the entire smelting plant does its work may be judged from the fact that its recovery is in excess of 97.5 per cent of the copper contents of the concentrates.

The advent of the Chile Copper Company among the ranks of copper producers during the past year has been an event of exceptional importance, partly on account of the huge size of the ore deposits, which will probably eventually result in the enlargement of the reduction plant to a size hitherto unapproached, and partly on account of the fact that this is the first large copper property to depend exclusively upon an electrolytic leaching process. While difficulties have been encountered in starting this plant, nevertheless the production of copper during the past year has been fairly satisfactory and the outlook for the future is very good indeed. The process has been demonstrated successful and the difficulties which remain to be overcome are mostly mechanical.

Work has been pushed as rapidly as possible on the leaching plant of the New Cornelia Copper Company at Ajo and is nearing completion. It is expected that the plant will be making copper in February. The process used has been fully described by Dr. Morse and Mr. Tobelmann in the Transactions of the American Institute of Mining Engineers, and is along the same general lines as that used by the Chile Copper Company. There is, however, no chlorine in the ore, and very little in the water, so that it is unnecessary to use the dechloridizing drums, which are so essential a part of the plant at Chuquicamata. It is the intention to use sulphur dioxide for controlling the ferric iron in the solutions at Ajo.

During the past year a rather unusual condition has developed in that the production of blister copper threatened to overtax the refining capacity of the country. This was foreseen, of course, and large additions were made to most of the refining plants. A new refinery was constructed by the A. C. M. Co. at Great Falls capable of a monthly output of 15,000,000 lb. This plant is up to date in every respect, and makes use of a current density rather larger than is customary in the East, viz., 22 amp. per square foot.

Owing to the low-priced hydroelectric power available, calculations showed this to be the most economical current density at which to operate when all things, including fixed charges on the investment, were taken into consideration. This plant has been operating steadily since last March.

Gold and Silver Metallurgy in 1916

The gold metallurgist has given but divided attention to metallurgical progress during the year. He has been actively occupied with the problems arising from the upward trend in cost of the supplies required for producing his finished material, which, almost alone among commodities, has not appreciated in value. Prosperity has passed him by. He is the mourner at the feast.

Such unsettled market conditions, though responsible for many present inconveniences, hold some promise for the future, through the development of American sources of supply. Thus cyanide of American manufacture has entirely replaced the German product, and it may be said that in quality and uniformity it is equal to the best heretofore imported. Potassium cyanide has quite disappeared from the market, without ill effect on the output of American mines. Incidentally, we note with satisfaction that the manufacturers have ceased to refer their analyses to the potassium cyanide standard, and are quoting the content of sodium cyanide—certainly the only rational classification. If operators will follow this example and finally discontinue reference to "128 per cent cyanide" and kindred absurdities, the cause of precision, at least, will have benefited.

Silesian zinc-dust, formerly the best material available, has been unobtainable since the early months of the war, so that operators have now two years' experience with the American dust. This, at first greatly inferior, has been improved until from at least one source is obtained a dust even superior to the best Silesian grade. The advance in price has stimulated investigations directed to the improvement of precipitation methods and of precipitants, and it is probable that interesting developments in this branch of cyanidation may be expected within the current year. In this connection the recently reported preparation of electrolytic zinc dust is of interest.

Another step in conservation, due to the impelling force of rising prices, may be noted in recent practice at the Homestake, where certain classes of precipitate are retorted for the recovery of the quicksilver content, prior to smelting for gold and silver.

The silver metallurgist passed, in the meanwhile, through much the same experiences. At the nadir of his fortunes a year ago, he has been relieved during the past eight months by a strong market for his metal, so that for him the burden of war prices has been lightened.

The Cobalt district witnessed tremendous appreciation in the cost of aluminium dust and of sodium hydrate, both of which are largely used in the processes more or less peculiar to that district. Perhaps the most striking feature of recent work there is the increasing attention being given to the salvage of minor metals in the ore.

Steady progress has been recorded in the application of flotation to the metallurgy of gold and silver. At Goldfield and in the San Juan plants are in successful operation; at Cripple Creek and Cobalt the process is receiving attention as a means for the beneficiation of difficult ores. A consideration of the ores under treatment in these districts—copper-bearing sulphides, mixed sulphides of lead, zinc and iron, tellurides and arsenides—indicates clearly the field best suited for its application. It is our impression that the year has done much to establish the practical limitations to its usefulness.

Ores relatively amenable to cyanidation, not requiring roasting or other preparatory treatments and containing no metals of secondary but commercial value, offer little opportunity for flotation to displace established methods. When in such circumstances the newer process is favored, it may be presumed that because of small ore reserves or limited capital unusual stress has been placed on the smaller initial cost of plant. This, one of the strong claims of flotation to consideration, is offset by the fact that it is not a complete process, but must depend on smelting or other subsequent treatment for the final recovery of its metals in marketable form. In the development of the flotation process the equipment of the cyanide operator has been drawn on freely, and several devices, notably Door and Oliver machines, have become standard equipment in the flotation mill.

New mill construction indicates that the gold-mining industry has generally accepted the crushing methods of modern copper mills. The Alaska-Gastineau has scored a sound technical success in its milling operations, however its position marketwise has been affected by the disappointing developments in the mine.

The first successful application of the ball-mill to gold ores was made, we believe, at the Vipond. Now we hear that these mills are to be installed at the Dome, displacing stamps of comparatively recent design. This advance seems reasonable, and we look for its continuance. Too much stress has always been placed on the supposed simplicity of the stamp. The past generation of engineers often spoke of "muscular metallurgy." The phrase was probably coined by a stamp-mill operator. As an amalgamating device, the stamp is preeminent, but complete recovery by this means is seldom attempted in these days, and it is probably sufficient thus to care for the coarser particles of gold.

It is to be regretted that published data of ball-mill performance have generally failed to take account of the accessory crushing machines which must both precede and follow it in the flow-sheet if it is to duplicate the product of the stamp. Among these data of crushing, the recent paper by Blickensderfer, in which a test of the Marathon mill is described, is of more than passing interest. This mill is a competitor of the ball-mill, but carries a charge of steel rods instead of balls. The fact that the marathon mill was compared with that of a pebble-mill, instead of a ball-mill, perhaps accounts for the remarkably good results, which are difficult to understand at first glance. Students of the mathematics of crushing should analyze for us the forces acting through this mill, of which we shall doubtless hear further, as the reported results indicate that the machine has a future.

In mill design other than crushing, the trend to

counter-current decantation has continued, at the expense, in great measure, of the basket types of filter. Thickeners of the tray type are proving very valuable. At the Liberty Bell, crucible smelting of precipitate, with preliminary sintering, has been put upon a rational basis. Weinig's description of the method merits consideration, particularly from the operators of relatively small plants.

Iron and Steel in 1916

The "prince or pauper" industry outdid itself in 1916. It became a prince in 1915, but what title to give it for 1916 we do not know. It was not a dictator, for it is commonly said that the tremendous price advances that occurred were brought about by the buyers, not the sellers, through the buyers importuning the mills to place their orders on books, even going to the length sometimes of requesting that the orders be entered and the price be set against the tonnage when it suited the convenience of the mill. "Delivery at mill convenience" became a common phrase in market reports.

Using weighted averages, the advances in pig iron per gross ton and in finished steel per net ton, have been as follows:

	Pig iron	Steel
1915	$5.50	$13.00
1916	11.00	29.00

Steel prices reached by the end of 1915 represented the traditionally "safe" level, the level attained in 1907, but not reached in the advancing movements of 1909 or 1912, though they were substantial and satisfactory movements in their time. Immediately, or as a matter of fact on Jan. 6, 1916, there was published the "stop, look, listen" statement of Chairman Gary of the United States Steel Corporation. Whether he expected his advice to be heeded, or merely wished to wash his hands of responsibility for what should occur thereafter, is not known. At various times in the past the Steel Corporation has applied the brakes, as it has sometimes also supplied an accelerating influence.

Steel price advances in 1916 were most rapid in January, February and March, and in August to November inclusive. There was almost a lull between times. The market showed its usual signs of possessing inertia, whether static or kinetic. Circumstances were such as to arouse some suspicions that an advance in steel bars made Aug. 1 by a prominent steel company represented an effort to get things started again. The bar market has shown some indications of weakness in July. If it was an effort, the effort was successful.

The 1916 advance in steel products brought prices late in October level with the top prices reached in the "boom" of 1899, but the prices taken for 1916 are prices for delivery at mill convenience, while in 1899 there were no such prices, the market being substantially a premium market. Prices advanced nearly $10 a ton more, at any rate, and all that was clear space on the chart of prices for the steel industry's whole history, covering a period of only about a quarter century, as it was early in the decade of the eighteen-nineties that mild steel supplanted the product of the puddling furnace as the dominant rolled product. Rail carbon steel had, of course, replaced wrought iron for rails much earlie, but it offered a vastly superior commodity, beyond question in any quarter. Comparing steel bar prices at the end of 1916 with historic iron bar prices, one finds as high prices, or higher, only from September, 1879, to April, 1880, and in various periods prior to the spring of 1874. The high priced period which ended in 1874 has lasted for about a decade.

We estimate production in 1916, in gross tons, as follows, compared with previous records:

	Estimate, 1916	Former Record
Pig iron	39,400,000	30,966,152 (1913)
Steel ingots and castings	42,500,000	32,151,036 (1915)
Rolled steel	30,500,000	23,112,986 (1913)
Rolled iron	1,500,000	1,678,257* (1913)

*Surpassed in various preceding years. Record unknown.

Pig iron broke its former record by 27 per cent, while steel ingots and castings broke their former record by 32 per cent. The divergence was due partly to the iron founding industry being not proportionately as busy as the steel industry in 1916, and partly to the fact that owing to the manufacture of a large tonnage of shell steel, with heavy discards, there was more scrap available and less pig iron was needed. The proportion of rolled steel to ingots produced was lower in 1915 and 1916 than in normal years, for the same reason, and as 1915 was not a sure criterion of the disturbance in proportions produced the estimates for 1916 must be taken with a larger allowance than is usually necessary. Approximate estimates are useful as the official statistics will not appear for months.

Not a single new blast furnace was blown in during 1914, and there were only three for 1915. As only 31,000,000 tons of pig iron had been produced in 1913, although the industry ran substantially at capacity through the first ten months of the year, there was a disposition to rate the actual productive capacity, at the close of 1915, at not more than about 35,000,000 tons. Although only two new furnaces were blown in during the first half of 1916, and only one or two in the second half, the actual production exceeded the estimated capacity by more than 10 per cent. This performance is attributed chiefly to changes made in the lines of many furnaces, chiefly by way of enlarging the hearth, though progressively harder driving year by year, and minor improvements, have played their part.

The excellent performance of the blast furnaces averted the pig iron famine that had been predicted for the early part of 1916. It had been noted for a number of years that steel works capacity was increasing much more rapidly than blast furnace capacity, measuring the latter merely by the number of new stacks. It was about June, 1915, when the market movement was still in its infancy, that the first announcement was made of any fresh increase to be made in steel making capacity. Afterwards the new projects came thick and fast. Fully 3,000,000 tons of steel ingot capacity was added in 1916, and there would have been more had not construction work proceeded so slowly. There is fully 4,000,000 to 5,000,000 tons of capacity now under construction or

definitely projected, with almost as large a tonnage of blast furnace capacity.

The perennial question has been "Where does all the steel go?" This question has been asked in times of depression, when there seemed to be no demand at all, for in the poorest steel years the output has exceeded that of seven years earlier, and usually it is asked also when demand is heavy. In 1916 "war demand" appeared to most observers to furnish an adequate explanation, but that was hardly the case. The rolled iron and steel exported directly, or consumed in the manufacture of everything that was exported, railway rolling stock, machinery, loaded and unloaded shells, etc., was approximately 8,000,000 tons, or 25 per cent of the production. In 1912 and 1913, the best export years, the proportion of export material was about 11 per cent. The remainder, for purely domestic consumption, was about 22,000,000 tons in 1912 and 1913 and 24,000,000 tons in 1916.

In some quarters the domestic consumption was relatively light in 1916. Cars and locomotives ordered in 1915 and 1916 were much fewer than in several of the earlier years, when the steel making capacity was much less. Monthly reports of the Bridge Builders' and Structural Society showed average bookings in 1916 representing 70 per cent of the fabricating capacity, distinctly a poor record. The production of galvanized sheets was very light. The production of rails for domestic consumption was much less than in 1912 or 1913. The consumption of the ordinary every-day commodities, the things the people at large use, as distinguished from consumption by the railroads and consumption in great construction works, must have been very much larger than in any preceding year. There was a reason for this. Most of the people had plenty of money, while the capitalists did not care to invest heavily, against the prospect of future earnings, at a time when materials and labor were extremely dear.

This analysis naturally suggests the future. By the middle of December the iron and steel market had slowed down, had almost come to a halt, due probably to a combination of circumstances rather than to the single incident of Germany making a peace overture. There is more interest in the future. The present appears to be a case of filling the large mass of orders on hand, with the country's transportation system in very poor working order, car shortages almost everywhere and embargoes without number.

After the war, whenever that period starts, there will be different prices, prices more or less in keeping with the conditions expected for a number of years. Projects long deferred will be launched. The past three years, at least, have constituted a period of very light new construction, and requirements have banked up.

Niagara Falls in 1916

To those who realize the intimate relation of electrochemistry to our daily life it is no matter of surprise that the past year was one of extraordinary activity in Niagara Falls and that its development as the greatest electrochemical center in the world reached a maximum. Not one of the electrochemical factories at Niagara failed to feel the stimulation of the increased industrial activity throughout the country.

It would be difficult, perhaps impossible, to say what particular industry was affected most. A mere study of prices would at once show what the conditions were as regards products like aluminium, ferroalloys, chlorine, etc., but there are other products in regard to which prices do not give any indication of the extraordinary developments, such as abrasive materials, graphite and carbon electrodes. Nor again would the price list show the new plants started at Niagara Falls.

There is perhaps a tendency to believe that this great activity in electrochemistry has been mainly due to war orders, perhaps because of the considerable popularity given to accounts of the importance of electrochemical products as a factor in national defense. However, while a certain percentage of Niagara Falls products in 1916 may be classed as direct war orders, the great bulk of the increased production was only related in an indirect way to the war. It would, of course, be folly to pretend that the enormously increased prosperity enjoyed by the electrochemical industries was normal and would have existed quite apart from the war; but it is true that the greater part of it has not been due to mere war orders, but was simply inevitable because of the general increase in prosperity throughout the country.

The truth is that there is no industrial center in the country which is more intimately associated with the daily life of every man in the United States. The laborer, the farmer, the clerk, the banker, in fact every simple inhabitant of the United States, is closely dependent on the electrochemical industries of Niagara Falls every moment of his life from the time he leaves his bed till he returns there at night. Unfortunately this dependence on electrochemical products is by no means realized by the man in the street. He does not know that in his every-day life there is hardly a moment that he is not using something directly or indirectly a product of the electrochemical industries, and that the production of this product depends on the utilization of what he has been taught to believe is a great "national spectacle" of right belonging to him, but threatened by a mysterious monster called a Power Trust.

We have said that the Niagara Falls industries have reached a maximum because it is now too plain that the curve of progress must become a horizontal line or even deflect downwards. With the increased production of electrochemical products in 1916 there has been a corresponding increase in the demand for power and long before the close of the year the limit allowed by the so-called Burton Act was reached. True the Burton Act was dead and the power of granting further diversion of water was in the hands of the Secretary of War; but unfortunately he was doubtful of his right to exercise the power, and his doubts were probably strongly reinforced by the fear of popular

superstitions deliberately fostered by unscrupulous propagandists.

The serious situation resulting from the power shortage was further increased by the demands of the Canadians. Here, too, there was an enormous increase in the demand for power in 1916 and the government was asked to exercise its right to cut off the supply of power exported from Canada to the United States.

Thus, while the year 1916 has witnessed a wonderful growth in the Niagara Falls electrochemical industries of which the country may be justly proud, it has also presented the sad spectacle of this great and beneficial development threatened with arrest largely for the purpose of keeping a Harrisburg printing press busy.

Electrometallurgy in 1916

During 1916 there has been a greater commercial development of electrometallurgical industries in the United States than at any time during recent years. What we said of the Niagara Falls electrochemical industries—that their immense activity and prosperity simply reflected the broad industrial activity of the country—is also true of electrometallurgy, and again in this case some direct influences of the European war are easily discernible. The heavy consumption of alloy steels formerly made largely in the crucible, the increased demand for ferro-alloys caused by the greater production of alloy steels, the shutting-off of imports of ferro-alloys and other electrometallurgical products, like aluminium and magnesium, the high prices of metals permitting experimentation with new processes —all these are contributory causes of the recent industrial advance in electrometallurgy.

After the installations of electric steel furnaces in this country had approximately doubled in 1915, the progress of the electric steel furnace has continued at almost undiminished rate in 1916. The chief trouble met with is a lack of experienced operating men. But high-speed tool steel is now being manufactured in 6-ton heats as a regular procedure, in contrast with the 100-lb. pour of the crucible. The heavy demand for high-speed tool steel and the difficulty of securing crucibles at any price has made the electric steel furnace an economic necessity, and it is here to stay.

A considerable number of electric furnaces have been installed in foundries for the manufacture of steel castings. More installations are contemplated involving the use of the electric furnace in a duplex process with the open-hearth or the converter. Several electric furnaces are melting ferromanganese before addition to steel.

In Germany—formerly the largest producers of electric-furnace steel—the heavy demand for tool steel has also resulted in an increased use of the electric furnace for steel making. In August the production reached 17,000 tons per month, or six times the monthly production at the outbreak of the war. On the other hand, the production of crucible steel in Germany has remained stationary, there being no new installations of any size. The monthly production of electric-furnace steel in Germany is now double the crucible output.

On a smaller scale there has been a heavy increase of ferro-alloy manufacture in the United States. Three new manufacturers of ferrosilicon started production during the year. At the outbreak of the war about half of the domestic ferrosilicon consumption was imported, but now practically all ferrosilicon needed for consumption is manufactured here, and a small amount is being exported. To provide part of the needed furnace capacity a calcium carbide plant in Niagara was switched over to ferrosilicon manufacture. During the period in question the domestic consumption of ferrosilicon has doubled and is estimated at 45,000 tons annually.

The largest domestic producer of ferrochrome was able to supply the increased needs of the steel industry, but it is probable that if this producer had not carried large stocks of foreign ore, there would have been a shortage of ferrochrome. The development of California mines has been slow and the average grade of the chromite was too low for alloy manufacture. With other alloys, such as ferrotungsten, ferrovanadium, ferrotitanium, and ferromolybdenum there has been an increase of production and several plants have been established. There is now sufficient plant capacity in this country for filling all domestic requirements of ferrotungsten, and for the first time considerable quantities of ferrotungsten are being exported. Exports of ferrovanadium have doubled since 1915. Most of the new producers are using the electric furnace. Ferrotitanium is produced at Niagara to the limits of plant capacity and the demand is greater than the power supply. A fair quantity of ferromolybdenum is being manufactured in the United States, and toward the end of the year there was a marked increase in demand for foreign shipment which is believed to have to do with the lining of big guns. Ferro-uranium was produced commercially for the first time in this country, and may be added to the new products of the electric furnace.

Aluminium manufacture in the United States enjoyed in the past year undoubtedly maximum production and maximum prosperity in its history, the lead over European producers being increased. The North Carolina plant of the Southern Aluminium Company, which in 1915 passed into the hands of the Aluminum Company of America, is expected to start operation in the near future. Further large projects for increased plant capacity are under way. The imports dropped to about one-tenth of the normal quantity and exports doubled. There are no new producers besides the Aluminum Company of America, up to the present. J. W. Richards, perhaps the best connoisseur of aluminium metallurgy, estimates that by 1925 aluminium will be third in importance among metals (measured by weight), and will be outranked only by copper and iron. This is an interesting prophecy, and a safe one, too, as 1925 is sufficiently far off. Qui vivra verra.

As a result of operations started in 1915 several plants are producing on a small but commercial scale by electrolysis very pure metallic magnesium.

Among new electrometallurgical enterprises electrolytic zinc looms large. There is the electrolytic zinc

plant of the Anaconda Copper Company at Great Falls, Montana, with a production of 100 tons of electrolytic zinc per day, while as a result of the Bully Hill experiments of the General Electric Company a $350,000 electrolytic zinc plant is being erected at the Mammoth smelter in California. As in 1915, there was in 1916 practically no development of electric-furnace smelting of zinc ore, so that in a time most opportune for commercial development nothing has been accomplished. It would seem that electrolytic zinc has the upper hand, and may be able to keep it, although in a measure its sudden development to a commercial process has probably been accelerated by the facilities of the Anaconda company available for placing an experimental development on a commercial basis.

The electrolytic copper refineries that were hit so hard at the start of the war have all been working to the limit of their capacity. Electrolytic refining has also made a success with tin; for years we have heard from European tin producers that Bolivian tin ores would always be out of question as the tin produced would be too impure; the success of the combined tin smelting and electrolytic refining plant of the American Smelting & Refining Company at Perth Amboy has proven that the additional refining cost is by no means prohibitive, and the only reason why enlargements have not yet been made is the present high cost of building materials. The plant is to stay and to grow.

The Front Office

He is a successful chemical engineer and is called upon for advice by the great and powerful. Neither contact with the affluent nor his need of a larger safe-deposit box for his growing bundle of securities has turned his head. Success has mellowed him, made him more thoughtful of the general welfare and caused him to grow in grace and amiability.

It was at the end of a long and very hard day. "I think," said he, "that if I had the administration of a great corporation in hand, I should ask for a special appropriation of ten thousand dollars a year in order to provide two five-thousand-dollar men. And I should put one out in the front office to meet visitors as they come in and the other should answer the telephone. I think it would be a profitable investment.

"Lately I wanted to buy some property. One of the big corporations with stock duly listed on the Exchange owned a factory site for which they had no use and which they were anxious to sell. It was just about what I wanted. They had been trying to sell for several years, and I doubt if many bids had been received. So I went to see them. Now I do not set up to be Phoebus Apollo or Hermes, or even a handsome man, but I do not think I look like one bent on robbing safes. Yet if I had been a tramp or a yegg I could not have received a less cordial reception. There was a very glib young person in attendance who acted—no matter what he thought—as though his chief duty was to get me to go away. He did not know anything and could not understand explanations. In vain I urged him to bring me into communication with an officer of the company. My reasons did not satisfy him. Finally I broke through his barrier and went inside, just a little flustered, but not too nervous to lower my bid. They were still very anxious to sell, and were very glad to see me. But why insult me on the way to see them?

"Again, the other day, I was in the market for a product that just now is produced in large quantities, but most concerns are sold out ahead. I called up one of the chief producers, gave my name, and asked as politely as I could. They know that I am often in the market, so it would seem that I ought to be a welcome guest sometime in the future. I explained what I wanted and what deliveries I needed, but 'Sold out. Nothin' doin'. Click,' was the answer that I received, and the last word, click, was a noise made by hanging up a telephone receiver; it was not a spoken word. I do not want them to kowtow before me, but I do like a rather full answer to questions. Rebuffs like that upset me and make me want to avoid communicating with them again if I can help it."

The fact is, the front office needs reorganization in a great many establishments. The men in authority are busy and do not want to be bothered. The ill-paid homunculus that sits at his desk outside the inner sanctuary does not want to disturb them lest he incur their ill favor. But the man from without bringing good will and business is put through a distressing initiation before he can enter the sacred portals of the place where goods that he may want to buy are for sale.

The front office homunculi or the elderly dunderheads in buttons and the braying asses at the telephones may all be useful animals, but they are not in their right places.

They should be supplanted by men (or women, for it's brains, not sex, that we are discussing) who are polite in their minds, who are able to apologize with grace to the man whose temper is undergoing exhaustion by long waiting, and they should know enough about the business to save half the waiting now necessary.

If we were to give the names of the great and otherwise well-managed concerns which maintain a veritable Bureau of Insult in their front offices and at their telephones we might easily be sued for libel. The captains of industry, at their desks a few doors away in the same offices, seem to use up all the politeness in their commercial servants. They are not aware of the naughtiness with which they even up their self-esteem upon visitors.

The small buyer, whose needs are as important to him as are those of the thousand-ton man, has no chance at all. When the war is over he will go back to the importer. The importer will make him welcome, and the small buyer will not find a single big head in the importer's office during business hours.

Politeness coupled with ability is scarce and expensive, but in the case of young persons who have the ability but not the gift of gracious bearing, there used to be methods current to put what was termed the fear of God into their hearts. It might be well to revive the custom.

Readers' Views and Comments

Mexico—What Will the Final Outcome Be?

(From an American Engineer, for Years in Mexico.)

To the Editor of Metallurgical & Chemical Engineering

Sir: What will the final outcome be in Mexico? This is an interesting question to many people, though not to any large proportion of the American people. To us Americans in Mexico who have material interests the question is not only interesting—it is important. Whether our going there to carry on business was an offense against public morality or not, the cold fact that our money and our properties are tied up there concerns us vitally, and we wonder what we can do toward conserving our interests.

It is impossible to discuss the commercial aspects of the case without bringing in the political aspects. There has been as much political bungling of relations with Mexico as there was between Bulgaria and the Entente Allies—which permitted Bulgaria to take sides with the Central Powers. Mexico has wanted for years to get on a friendly footing with the United States, and Americans who have gone into Mexico during the last ten or fifteen years have done their best to convince the Mexican that that old feeling of distrust toward Americans was unwarranted and uncalled for. It has worried the Mexican to see all the commerce and the active industries of his country going into the control of foreigners; and he has had an innate fear that some day the material influence of the domination of commerce would lead to the desire to exert a corresponding influence in political affairs. So he has distrusted the foreigner in general, and has singled out the American in particular mostly because of personalities.

When we pin down any Mexican to tell us what the real fundamental causes are or have been for the universal feeling against Americans more than against other foreigners, he is hard put to explain himself; he must speak of personalities, and his delicacy makes him hesitate to speak out. He will admit that any American-managed institution will operate in conformity with the laws of the country, will pay its employees better wages, will give them more hospital services, and more schools for their children, and will abstain from mixing in politics more so than concerns managed by other foreigners. Then what is the trouble?

Well, says the Mexican, you do not understand us personally, our customs; you look down on us with scorn, and force on us your beliefs that we are an uncouth, undesirable people, not to be considered your equals in any phase of life. You show it explicitly in that you will not intermarry with us. All other foreigners will marry here, but the American, as a whole, seems to have decided scruples against it. On our side, we think that Americans are brusque, blunt, cold-blooded, too clever for us in business, impolite, lacking in culture and refinement.

The American in Mexico realizes the handicap under which he labors in that the Mexicans as a whole have an aversion to the Americans as a whole, so he endeavors to overcome it by patient, tactful manner in his dealings with the Mexicans. But it is against the lifetime customs of the American to have to use the special tact needed in Mexico; at home he uses special-delivery mail, the telephone and the telegram to expedite his business with brusqueness and rapid-fire decision; this bores the Latin-American at every turn. So many an American in Mexico makes but a sorry mess of it, and usually makes himself more disliked than ever. The Americans who have been a long time in Mexico have improved themselves in this detail; their experiences have taught them to do it. But the newcomer and the people at home show no improvement.

"Foreign policy" is a term or expression as foreign to the mind of the average American as is the term "tact." At home we think the sun rises and sets around our good old United States; all foreign peoples should learn our language and should be glad to have our business on our own terms. The American who goes to a foreign country condescends to learn about as little of the language of that country as is absolutely needed still to bat around at his business, comprehending little and miscomprehending much of the language, ways and customs of the natives.

So the average newspaper writer, associated press correspondent, confidential agent, personal spy and all of the ilk, are as competent to understand the Mexican question and to write reports on it as would be some Hungarian journalists that could speak no English and had never been in the United States, should they be sent over to write up the negro question of the South.

Porfirio Diaz knew that Mexico's natural resources would never serve the upbuilding of the country if native capital were to be depended on for the exploitation. He deliberately planned and carried out a program that induced the coming of foreigners and of foreign money into the country. Among the foreigners were many Americans. Foreign governments at the same time materially aided their nationals to come to Mexico to do business. Among these foreign governments the American government for thirty years encouraged its nationals to go to Mexico. The United States Federal government has brought about the building of the Pacific railways by the scheme of granting lands and other natural resources to the railway builders. The time for the necessity for such measures has passed, but there was a time when it was necessary. Mexico also has aided the building of railways by using the same plan. In the States we spoke of "land grants," in Mexico they are called "concessions."

To-day, in the States, when some corporation looks over the field for an opportunity to set up a factory of some kind, all the towns in the territory considered get busy and offer free land and tax exemption in order to secure the location of the factory. The scheme is considered honorable and to be commended. When Porfirio Diaz wanted cotton factories built up in Mexico he followed the same plan, but our American people and our home government qualify those acts of his as acts of giving away the country's resources, and the factory builders are called concession hunters and public grafters, and it is argued that these people should ask for no sympathy should they lose their interests later on.

I have lately been in middle Pennsylvania, and I observed many silk mills, all owned by one parent company in Germany. The mill managers and superintendents are German; many of their skilled operatives are German. Every new mill installation receives free or nearly free land for building sites; all have received tax exemption. Did Germany's home government encourage the building of these institutions? Did she discredit her citizens because of their enterprises? Does the American government encourage such build-

ing, and does it, or do the American people discredit these Germans because of their coming over here to do business?

Then why are we Americans of Mexico so discredited, so berated, for having gone into Mexico, subject to the laws of Mexico, just as those German capitalists and German operatives came to the States? If for thirty years the Mexican government has encouraged us to come to Mexico, and for the same thirty years our own American government has encouraged us to go to Mexico, does our own American government not owe us now a proper consideration? Does the particular feature or incident that Mr. Woodrow Wilson is now President absolve the American government from its moral and material obligations to us that have resulted from a thirty years' continuous policy of encouraging American commerce in Mexico?

It is an outright misrepresentation of facts to say that the exploitation of natural resources and of ordinary commerce in Mexico by foreigners is as a whole based on "concessions" or improper privileges that operate to bleed the country for the undue benefit of the foreigner. There may have been an occasional instance in the earlier years of Mexico's development, just as there may have been in the States, when undue profits were made. But 98 per cent of the "concessions" given in Mexico are as just and as conformable to the laws in vigor as can be found in the States. The crass ignorance, the petty pigheaded indifference of our home people and our home government to the correct meaning of the word "concession" as used in the Spanish language excites our derision. In the States a corporation secures a "charter" that gives legal permission to operate the expected business under the restrictions placed by law. A peanut vendor must also secure his legal permission, and it will be called a "permit" or "license." In Mexico these same permissions would be called "concessions" and would have honorable significations; but the American signification of the Spanish word "concession" infers something dishonorable. This idea has really become an obsession in the States.

We Americans derive much amusement from deriding the German "Kultur." Probably their "Kultur" is open to derision and censure. But the new American "Kultur" lately expounded by our home people and government—"that the flag does not follow an American when he goes to a foreign country"—is many times more despicable, more unworthy of a great nation. And we think it is really dangerous for the welfare of the nation.

All this is said in an endeavor to demonstrate that the American with material interests in Mexico is entitled to the good will, the moral support, the material support and the protection of his home government. Besides this, the American government has arrogated to itself the supervision of the affairs of all foreigners in Mexico, and will therefore have to render accounts some day to all foreign governments.

Our money is invested in Mexico; our business is not going on; our holdings are being injured because the existing authority in Mexico is persecuting our holdings with an apparent view of forcing us to abandon them completely and thereby suffer financial ruin. They do not clearly confiscate, but they do actually sequestrate our properties. Shall we quietly submit to conditions and let everything go by the board? Shall we try to meet every day's new, arbitrary decrees calling for more and more ready cash put in, so as to try to see the game through until the extortion be satisfied and we be permitted to carry on business under legitimate conditions?

It is hard to decide. Undoubtedly all institutions of limited financial resources will be hard hit, and many of them will be ruined. The big, strong concerns will die harder.

Is there any hope that the Carrancista organization will be able to establish finally a stable government and bring peace to Mexico? None whatever. They are as able and competent to govern Mexico, and as deserving of the good will and support of good people, as the Industrial Workers of the World would be if given a chance at governing the United States.

Can Villa ever come back, and could we put any hopes in a government that he might establish? No. Villa lost the chances he had when he became his own true self and tried to assault the young French lady in Mexico City on his entrance there. The painful fact that he could never "be," any more than Huerta could "be," was forcibly brought home to President Wilson by the French Government's outright declaration. The next problem for President Wilson was that of finding a pretext for disowning Villa without letting the gentle public know the regretable reason. So we have the statement that when later the famous call was made to all combatants to come to camp to settle their differences, the Villista chieftains answered: Agreed. The Carrancista chieftains answered: Agreed, but in the end we shall agree to whatever our First Chief shall decide. Wisdom of Solomon. Villistas are but individual parties bound together by but a gentleman's or bandits' agreement. Carrancistas have formal organization, discipline, and are therefore entitled to preference. Decison by the Court: Recognize Carranza with all the pomp and ceremony of war.

Was there any rhyme, reason or sense in any one's being recognized? It appeared to be thought that simple "recognition" was all that was needed to stabilize any government in Mexico. The American government seemed to think that its recognition would make or unmake any old government. We have seen that its recognition of Carranza has not made nor can "make" his government. We saw that its withholding or recognition of Huerta made much trouble for the old man, and possibly did "unmake" him; though we are inclined to believe that the thousand-and-one ways employed to hamstring Huerta were what really "unmade" him.

Can Feliz Diaz carry through a successful revolution and establish a stable government? Not with the limited backing that he appears to have. If he were a real strong man and of personal resource he might make quite a bid for it.

What about Zapata? Zapata is a bushwhacker, pure and simple; a four-floosher, and a very poor aid in military sense, as Villa found from experience. But it will call for the services of the Apache Indians to make a thorough job of finishing him.

Can Carranza retain control of the government and also physical possession of the country in face of the combined opposition of Villa, Zapata, and Feliz Diaz? He cannot, unless he can obtain the material as well as the moral backing of the United States; and material backing must mean loan of sufficient money.

Can Carranza obtain that material backing? It is unsafe to guess at what President Wilson may do in the matter; he has shifted, side-stepped, back and filled, and eternally hesitated on the Mexican question until no mortal man can guess at what he may do next. I think that we can hazard one guess at one feature, and that is that if in the course of human events it again comes up to him to recognize or not to recognize some man as President of Mexico, he will immediately and in a loud voice declare that he will never, no never, recognize any man as President of Mexico.

Assuming that President Wilson exercises no particular initiative on the subject, can Carranza get the necessary loan? Not until his government adjusts it-

self to civilized customs; and it is improbable that it can do that, because its adherents, in the main, are so radical and arbitrary, and so hard to control that it is unlikely that it would be permitted to carry through any healthy, moderate program that it might wish to.

What effect has the European War on the Mexican question? It is commonly conceded that since the war came on it has been sufficient reason for refraining from radical action toward Mexico. But it is like the Irish question—when the war ends, the question will bob up again.

During Huerta's tenure of power, which was for a year and a half preceding the opening of the Great War, with all great nations, excepting the United States, having recognized Huerta, with all foreigners in Mexico vigorously protesting to their home governments about the state of affairs—the stock answer that other nations sent back to their nationals in Mexico was, "that your home government regards it as your patriotic duty to submit gracefully to what is going on; do it to aid your own country's best interests. The American Government's policy toward Mexico is producing results that we never before dared hope for. Its loss of prestige, and the resentment aroused throughout all Latin America are exceedingly pleasing to us. Its loss is our gain."

And to think that that state of affairs has continued for two and a half years more, and the end is not yet in sight.

Assuming that the European War continues for four years more, and that President Wilson makes no change in his Mexican policy, what is likely to occur in Mexico?

Disintegration of the Carrancista government; short-lived attempts by other men to take Carranza's place; growing power of Villa and of Feliz Diaz; more bush-whacking by Zapata; total anarchy in economic affairs and industry in general; more and more losses by foreign interests. And when the limit of endurance has been reached, the foreign, material-interests people will for the first time enter into Mexican politics; will organize for particular interests of Villa, of Feliz Diaz, of the old-time, respected Porfirio Diaz people, with a considerable proportion of foreigners in active service, into a compact, well-equipped organization that will sweep Mexico and will establish a government so strong and so stable that our present American dream of dominating politics from the Equator to the Canadian line will never come true.

Y. X.

The Recovery of Molybdic Acid from Phosphorus Filtrates

To the Editor of Metallurgical & Chemical Engineering

SIR:—The following method has been used by the writer for the last two years and has proven quite a saving, considering the present price of the reagent.

The filtrates from the determination of phosphorus are saved in a suitable container, microcosmic salt is added, and from time to time as the solution increases in volume it is tested to see that sufficient phosphate is present to throw down all the molybdate. When considerable yellow phospho-molybdate precipitate has accumulated decant off as much of the clear liquid as possible, and then filter off the yellow precipitate using suction, and wash several times with dilute nitric acid and then several times with water. Suck the precipitate as dry as possible. Now take a small weighed portion of this precipitate and dry at 105 deg. C. to determine the amount of moisture in it. After the moisture is known weigh out enough of the moist phospho-molybdate so that it contains 115 grams of the dried precipitate. Place this precipitate in a liter flask or beaker, add 100 c.c. of water and 100 c.c. of ammonium hydroxide and warm to about 80 deg. Stir the contents of the beaker thoroughly and if all the precipitate does not dissolve add ammonium hydroxide slowly with stirring until all has dissolved.

Cool this solution under the tap and add 150 c.c. of ammonium hydroxide and then a saturated solution containing 10 grams of magnesium nitrate. Shake vigorously several minutes and then allow the precipitate of ammonium magnesium phosphate to settle over night. Filter with suction, sucking the precipitate as dry as possible. Make this filtrate up to 750 c.c. with water, cool and add it to a cooled solution of 625 c.c. of water and 625 c.c. of nitric acid The reagent is now ready to be used to precipitate phosphorus from solutions.

The precipitate of ammonium magnesium phosphate is dissolved off the plug with dilute nitric acid and the acidified solution is added to the container in which the waste filtrates are kept, and in this way less microcosmic salt is necessary for throwing out the molybdate for further recoveries.

E. W. HAGMAIER.

Buffalo, N. Y.

Valency and Valence

To the Editor of Metallurgical & Chemical Engineering

SIR:—After reading the article entitled "Inadequacy and Inconsistency of Some Common Chemical Terms," by Carl Hering, on page 649 of your journal (Vol. XV, Dec. 1, 1916), I looked the matter up in some of the current textbooks of general chemistry and was more than surprised at the meagerness and looseness of the treatment of the topic of valence there exhibited. The subject is discussed so thoroughly and the principle is used to such an extent in the chemical instruction given in the courses at the Michigan College of Mines, under the supervision of Dr. C. M. Carson, that I had not imagined that the matter of valence would be handled so lightly elsewhere.

This condition of affairs exists probably because the importance of the concept of valence is not widely appreciated. And in this connection it might be well to suggest that the majority of the teachers of chemistry would welcome more frequent expressions of the opinions of chemical and metallurgical engineers relative to the greater or lesser importance to be assigned to the various features in courses of instruction in chemistry. One effort along this line resulted in the editorial on "Fashion and Style in Chemistry," on page 501 of your issue of Nov. 1, 1916 (Vol. XV).

In the instruction given at this institution the word valency is used to denote the more or less variable capacity of an atom of an elementary substance to combine with an atom or atoms of other simple substances as exhibited in its known combinations. No qualifying signs or numerals are applied in connection to this general property word. But such signs and numerals are applied in connection with the term valence which is defined as the kind, in terms of polarity, and the amount of the chemical combining capacity of an atom of an elementary substance, as manifested in the given case, relative to the combining capacity of the atom of the standard substance, hydrogen, to the atom of which a positive valence of one is assigned.

Here the concept of valence is used to enable a student to write the formulas of all possible normal salts without the excessive use of the memory that would otherwise be necessary. Most equations are balanced by a modifications of the valence method of O. C. Johnson, And the relation expressed in the equation—chemical equivalent $\times$ valence = exact atomic weight—is made use of in the calculation of these quantities. In the

electrochemical work the correspondence between valence and the ionic charges is emphasized and applied. Exercises and problems involving these ideas are given in sufficient number and variety so that the concept of valence can become a really useful tool.

It is only in the case of persons with sharp impressions requiring modification that there is any difficulty about the introduction of a new word to replace a less comprehensive one. If the terms reduction and adduction are properly explained and illustrated in the first instruction that a student receives in chemical work, he will have no subsequent difficulty in keeping them in their proper places alongside the less general terms deoxidation and oxidation. The use of the following scheme, shown as applied to chlorine, has been found helpful in instruction of this kind:

Valence change in adduction reactions.

$$\xrightarrow{\hspace{6cm}}$$

−1	0	+1	+3	+5	+7
Cl,	Cl,	Cl,	Cl,	Cl,	Cl.

$$\xleftarrow{\hspace{6cm}}$$

Valence change in reduction reactions.

F. B. WILSON.

Michigan College of Mines,
Houghton, Mich.

The Protection of Iron and Steel

To the Editor of Metallurgical & Chemical Engineering

SIR:—In a paper read last September before the American Electrochemical Society it was brought out that the coating metal must be electropositive to the metal to be protected. If the coating metal is electronegative, then the slightest break or pin hole in the coat will allow moisture to set up a galvanic couple; the iron or steel will then not only rust, but corrosion will go on at a greatly accelerated pace.

That is why tin, lead, brass, copper and nickel are all very poor protectors against the weather. These are all electronegative to iron or steel. The only available electropositive metal is zinc.

Unfortunately zinc is brittle and unless great care is exercised to not crack it, split, or foliate it, when working the coated articles, it leaves relatively large areas unprotected. It is not always feasible to redip or replate the articles after surfaces or seams have been damaged by bending, riveting, calking, etc.

Alloys of zinc with tin and lead are tough. Unfortunately it is difficult to put them down. In the hot bath the alloys have a tendency to segregation that is so serious as to demand great accuracy and care in securing and maintaining just the proper heat, not only in the bath, but also when the coated article is cooling; otherwise the brittleness of the zinc supervenes; when segregation has caused areas to be coated with the separated-out lead or tin, these areas are not zinc-coated and therefore as subject to rapid galvanic corrosion as though no zinc were used, but pure tin or lead.

A relatively new coating process is fortunately available. Zinc is reduced to a very fine powder, containing very little oxide or other impurity. This is mixed with a suitable flux to the consistency of a creamy paste that is applied cold with the brush, by dipping or spraying. The metal to be protected is, of course, first cleaned as it is for any method of protection. The article is then heated in any convenient way slightly above the melting point of the zinc. It is obvious that the means of putting on the cold Epicassit (the name given to the process) or the means for heating are relatively immaterial to the result, but governed chiefly by convenience, character and quantity of the article.

In order to secure a very tough and therefore ductile coating that will resist bending, twisting and hammering without cracking or splitting off, tin and lead are added to the pulverized zinc. The segregation found in large baths is absent, as the coat is, of course, very thin as compared with a bath. Nor can there be segregation as the coat is melted down, because the particles of zinc, lead and tin powder are separate and not alloyed as a rule; these particles are so small that the protective electrogalvanic action of the zinc extends to the adjacent lead and tin particles as well as to the iron or steel underneath. Epicassit-galvanized articles have much more of the bright, smooth character of tin plate than is the case with pure zinc.

This method is equally useful whether employed initially for entire surfaces or whether used to repair damage in galvanized work, whether caused by time or in field assembly. The coat may be applied externally or internally, over whole surfaces or only to certain areas. The articles may be coated by being brush-painted with the cold epicassit, by spraying or by dipping. The application of heat has just as wide latitude; baking ovens, heated tumblers and the blast torch are used. Any of the softer metals that can be reduced to a fine powder are used as pure tin, pure lead, pure zinc and their mixtures in various proportions. While it is but little demanded, it is entirely feasible to apply dissimilar coatings on the inside and outside of vessels.

One of the chief uses of Epicassit is that referred to of providing a very tough and adherent coating of zinc of great latitude as to method and ease of application.

HENRY HESS.

Philadelphia, Pa.

A Chemist's Vacation

By Edward Hart

Visiting time had come. For forty years I had taught and given much of my time to others. Now vacation days had dawned. No longer must I face a round of lectures, quizzes and the daily drudgeries of the teacher's task. I packed my grip and started south.

In the days when Dr. Mallett and Dr. Prescott and Henry Carrington Bolton and William McMurtrie were still with us, we had come together every summer as Section C of the American Association for the Advancement of Science, and in the evenings with others as Section Q—not announced on any calendar of our meetings. In the daylight we told chemical stories and in the evening others. Now the select company had grown until it seemed like a mob. I missed the old faces and longed to see them once more.

I reached Washington in the evening and after dinner made my first call on Farmer Wiley. He was, as befits a farmer, in his shirt sleeves with an apron around his slim waist making sausage. Mrs. Wiley was assisting and I joined the party. We made 24 lb. of sausage, good sausage. I ate some of it next morning—and talked; how we talked!

Next morning, I looked up Frank W. Clarke and listened while he told me about the composition of the skeletons of those living in the sea and the geologic conclusions to be drawn. And I responded, dilating upon the green sand of New Jersey, how I had discovered that it consisted of about 60 per cent common quartz sand each grain covered with 40 per cent of green glauconite. Then he read me this poem written in his early days:

THE POLITICIAN'S PRAYER.

BY F. W. CLARKE.

Our Father—whether in Heaven or Hell
 We hardly know—
Look down (or up) to where we dwell,
And while our supplications swell,
 Thy gifts bestow.

Give us the counting of the votes
 Election day,
Let none of our men turn their coats,
But send the opposition boats
 Salt River way.

Let slander, malice, fear and fraud
  This autumn fail!
But if such tricks should be abroad,
Expose our enemies, O Lord,
  Let ours prevail.

If base repeaters cheat the polls,
  Their crimes betray!
Strike terror to their guilty souls!—
But write their names on Mercy's rolls
  Who vote our way.

Give us by honest means success
  In all this fight.
But if misled by bitter stress,
We save the realm through crookedness,
  Lord, make it right!

We must, O Father, must succeed:
  This is Thy cause,
O! help us in our hour of need,
The pockets of the rich to bleed,
That we may vindicate our creed,
And make Thy laws.

But if the people should decide
  Against our case,
Let naught of evil me betide,
Let me find favor with the other side
And get a place.

Then I visited Dr. C. E. Munroe, the great census expert, famed as well for his knowledge of explosives, and we lunched at the Cosmos Club, where I found Frear of State College, Pa., and Bigelow of the National Canners' Association who was good enough next morning to show me what good work he had accomplished at his new task.

My good host had placed his auto and driver at my disposal and we drove to the Bureau of Standards where Dr. Hillebrand, famed for exact analytical work, showed me through his new laboratory.

From there I visited my friend Swavely of the Army and Navy School, a graduate of Lafayette College and an active and influential alumnus. During the day I made a visit to the Bureau of Chemistry of the Department of Agriculture and saw my friend Patterson at the meeting of the official Agricultural Chemists in session at the Willard. This was rapid work for two days but I had far to go. That night I bade Washington adieu and started for Charlottesville, Va., seat of its famous university. Here I was met by Dunnington, a young man when we last met, now talking of retiring. We visited Dr. Mallett's laboratory together—still as he left it—and talked about his great work. Dunnington had nothing to say about his own work. It was all Mallett. What a beautiful legacy is a loving memory like this! Dunnington, too, is building a new laboratory. It was here that Edgar Allan Poe and Woodrow Wilson and Richard K. Meade were students. In the distance Monticello could be seen.

In the afternoon I left for Staunton, which Virginians pronounce Staanton, on my way to Lexington, the seat of Washington and Lee University. After the civil war Robert Edward Lee, the greatest general the war produced, became president of the university which Washington had founded. Here he died and lies buried in a beautiful mausoleum with his wife and other members of his family. His study has not been touched since his death. If I had been a student here I should have been very proud of my alma mater. I was welcomed by my old friend, James Lewis Howe, famous for his work on the platinum metals and for his annual reviews of the progress of chemistry. Next morning I talked to the chemical students and met the bright young members of the teaching force.

In the afternoon we visited the Virginia Military Institute and met the professors of chemistry. It was here that Stonewall Jackson taught when the war broke out. Here he enlisted the first company of his famous foot cavalry, and here he is buried. Lexington should be proud of her great dead. Lexington is very proud of the beautiful Doremus Gymnasium and of the way in which the money for it was given.

It seems that Mr. and Mrs. Doremus visited many colleges and finally decided that Washington and Lee was the most deserving. These visits were unannounced and the gift of $2,000,000 was entirely unexpected. "Just think," said one of the professors, "what a reception he would have had had we known."

From Lexington a business call sent me back to Richmond, which I had not visited for many years. In the lobby of the Jefferson a Confederate veteran was selling Confederate money and Indian arrow heads. Richmond is a fine city, and appears to be growing rapidly. The chief occupation of the authorities is to find some new way of levying taxes. Even the capital of the merchants is to be taxed. I saw Dr. Carpenter, grown old in the service of the Virginia Carolina Chemical Company, and Dr. Wightman, the bright and active young professor of chemistry at Richmond College, who takes the place of Dr. Bingham, now my colleague at Lafayette.

From Richmond I journeyed to Chapel Hill, N. C., to visit my old friend, Dr. F. P. Venable. When I first knew him, Dr. Venable, who is the son of a former professor of mathematics at the University of Virginia, was professor of chemistry at Chapel Hill; then the trustees made him president. For fifteen years he bore this heavy burden and built fourteen buildings; then he asked to be allowed to go back to his first love. To mark their appreciation of his services the trustees created the Francis P. Venable Professorship of Chemistry and made him the incumbent for life.

Now he has begun life anew, and with Dr. Bell, a graduate of Dr. Lash Miller of Toronto, has undertaken to redetermine the atomic weight of zirconium.

North Carolina is a sort of chemical slop jar. In variety of minerals she is not to be excelled on the face of the earth. Zircon is one of these, and the atomic weight of zirconium has never been satisfactorily determined. Venable took me to his laboratory and showed me how he made zirconium chloride, how he had one by one overcome the innumerable difficulties until he now felt sure of ultimate success. I rejoiced with him, and told him what I had been doing. In the evening Dr. Herty came over to see me. Herty is president of the American Chemical Society and is to edit the "Journal of Industrial and Engineering Chemistry." In my further journey through the Southland I heard much of the Herty turpentine cup. Turpentine is a great industry in the South and Herty has done good work there.

Next day was Sunday, and we went to hear a sermon by Mr. Moss in the Presbyterian Church. It was a unique sermon—I never heard one like it—full of real meat. In the wall back of the pulpit were four marble tablets. One of these read as follows:

In memory of
Elisha Mitchell, D.D.
Born in Connecticut 1793,
Died on Black Mountain, N. C., 1857.
Professor of Mathematics and of Chemistry U. N. C.
1817-1857.
Ordained minister by Orange Presbytery 1821.
Stated supply of this church for many years.
One of the builders of this house 1849.

After service we strolled around the town and admired the fine old houses set back from the streets and the beautiful gardens. The atmosphere reminded me of Oxford—there was the air of friendliness and genial ease though not quite so straight-laced as the Oxford I last saw.

Some time since, talking with the successful young sculptor Harry Raul, I said to him, "Why must we forever continue to reproduce in our architecture the Greek acanthus leaf, the egg and dart and the walls of Troy? Why not have an architecture of our own

in which the Indian corn, the wheat, the strawberry, mullein, cotton plant, the cypress and the poplar play a part?" Here I found the answer to my query in the law building, in which this idea had been carried out with happy effect. It is worthy of further elaboration. Why not have an architecture of our own and discard our slavish following of Greek and Goth?

In the absence of her mother, Miss Frances Venable presided over the dinner, and Drs. Wheeler and Bell were also guests. We spent the afternoon telling stories. F. P. is a famous raconteur. His darky stories are especially good. Dr. Wilson, librarian, who dropped in during the evening, reminded us of the darky who said apollinaris tasted like your foot's asleep.

Next morning I rode my auto to Durham and then by train to Winston-Salem, where I found two of my old students, J. L. Ludlow, a prosperous civil engineer, and Robert A. Rice, business manager of Salem College. Ludlow is buying spent pyrites from the surphuric acid companies. It contains 2 per cent sulphur. He roasts it to a content of 0.05 per cent and at the same time clinkers it and sells the clinker to the iron blast furnaces. My two hours' stop here was soon at an end, and I went back to Greensboro on the way to Atlanta, my next stop. On the way to Greensboro we passed a station called Terra Cotta, where large stacks of the finished product show that the station was properly named. I found every where through the South evidences like this of an industrial awakening. Those who think the South still sleeps have not been abroad.

My visit to the Georgia School of Technology at Atlanta was a very pleasant one. I was very kindly treated, and although my visit was brief and made in a pouring rain it was very enjoyable. That evening I dined with Professor Daniel, who has done good work on the hydrogenation of oils; after dinner we went to the movies and talked shop instead of watching the pictures.

I reached New Orleans at 11 p. m. and went to the Grunewald, where, to my great surprise, I found my old friend Dr. A. L. Metz, chief of the chemical force of Tulane University, waiting to receive and welcome me.

Next day was Thanksgiving. In the morning I called up my old student G. G. Earl, chief engineer of the New Orleans Water Sewage and Drainage Commission. Mr. Earl drove me to one of the six pumping stations for lifting the sewage and drainage into Lake Pontchartrain. We saw two of the monster pumps designed and built under his direction capable of lifting 36,000 cu. ft. per minute. It certainly was a great pleasure to see what good work our graduate is doing.

At noon, with the chemical faculty of Tulane, I was Dr. Metz's guest at the Louisiane restaurant, after which we adjourned to his home, where we spent the afternoon and evening.

Next day, at Professor Williamson's invitation, I talked to the students in chemical engineering and aired my peculiar views on teaching. During that and the following days I visited the sugar plantation of Edward Godchaux at Reside, La., where I saw cane sugar made at the rate of 2000 tons daily, to the plant of the International Distilling Company at New Orleans, where cologne spirits and gin are made from black strap molasses, and two experimental plants, where potash is being recovered from the slop.

On my way home I stopped at Auburn, Ala., to see Dr. B. B. Ross, and we spent part of Sunday in a visit to Tuskegee, where John Washington kindly showed us over the interesting experiment. Another stop was made at Copperhill, Tenn., to see a new nitric acid plant with twenty-one Hart condensers just installed with all the modern improvements. It was very interesting to see how my modest experiment of 1891 had expanded in the course of time into a large industry.

Easton, Pa.

Coming Meetings and Events

American Institute of Chemical Engineers, New York, Jan. 10-13, 1917. (See p. 55.)

Society of Chemical Industry, New York Section, Perkin Medal Award, New York, Jan. 19, 1917.

Joint meeting of New York Section of American Electrochemical Society, American Chemical Society and Society of Chemical Industry, Rumford Hall, Chemists' Club, New York, Feb. 9, 1917.

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

Western Metallurgical Field

Ferro-Alloys

A 200-kw. electric furnace is being installed at Utah Junction, near Denver, for the production primarily of ferro-tungsten. The new company will operate under the name of the **Ferro-Alloy Co.** The contract for the plant has been let and it is hoped that operations will begin in 90 days. If the production and sale of the ferro-tungsten justifies it, other ferro-alloys will be manufactured. These are ferro-molybdenum, ferro-vanadium, ferro-manganese, ferro-uranium and ferro-silicon.

Case of the Government Against Trona Co.

The case of the government against the California Trona Company which has been trying to extract potash from Searles Lake was called on Nov. 27, and was continued pending a final agreement on stipulation so that the case will probably come up in a short time again. The government, in order to avoid a long drawn out legal battle, is endeavoring to put the case up to the Department of the Interior on the basis of a stipulation of facts.

The Trona Corporation has applied for patents in this case covering four 28-acre locations, furnishing a test case. An examination was made and charges preferred against the application, alleging:

First, the form and character of the deposit was not such as to be subject to location under placer mining laws.

Second, the application of the California Trona Company was not made for its own use and benefit, but for the use and benefit of a foreign corporation, thus making the application subject to disqualification.

The endeavor now in getting a stipulation of facts is to get a statement as to who owns the stock of the California Trona Corporation. It is known to be controlled by English interests. The procedure at present is to get statements on both sides and come to an agreement to prevent a legal battle.

The Trona Company has about completed a large plant at San Pedro (Los Angeles) and the machinery evaporators, centrifugals, etc., have been installed. The Searles Lake plant at Trona has been modified to a great extent, and much of the apparatus is believed to have been scrapped. As far as is known no production of potash has been made as yet by the Trona Company.

The following facts as to the plants at Trona and San Pedro are given in the *Mining and Oil Bulletin* for December of the Los Angeles Chamber of Mines and Oil.

The company's plant at Trona, Searles Lake, San Bernardino County, comprises a battery of 2000 hp. Bab-

cock & Wilcox boilers, housed in a steel and reinforced concrete building with a vertical flue of steel and concrete which is a monument to the designing and constructing engineers. This chimney is 150 ft. in height, and 9 ft. in diameter in the clear at the top. The evaporating building is 109 ft. high, 200 ft. long and 70 ft. wide, also constructed of steel and concrete. In addition a building 600 by 90 ft. houses the machinery for the production of potash salts and borax. The plant also includes a reinforced concrete spray pond for cooling the water used for the condensation of vapors; a 10,000 barrel oil tank; two 500,000 gal. steel tanks for brine, and several other tanks of 10,000 gal. each. The offices and laboratory are in a two-story reinforced concrete building. F. O. Engstrum Company, with offices at Fifth and Seaton Streets, Los Angeles, secured the contracts for the general construction work; all tanks used were furnished by the Llewellyn Iron Works, of Los Angeles and Torrance; steel and machinery were purchased from eastern dealers.

The camp equipment is modern in every detail, and comfortable bungalows are provided for the employees. A 32-mile standard gauge railroad has been completed, operating between Searles, a station on the Southern Pacific, and the company's plant at Trona. The brine is treated at Trona by evaporation and the concentrated product is to be shipped to the refinery at San Pedro.

When completed, the refinery at San Pedro which is not far from Point Fermin, will have a capacity of 200 tons of potash per day, and the output will also include a daily production of sixty or more tons of borax. Later the company will put on the market sodium carbonate, sulphate and chloride, and intends to erect additions to the plant for the manufacture of such potassium or sodium salts as the market may require.

The power plant at San Pedro contains 1000 hp. Babcock & Wilcox boilers, housed in a steel and reinforced concrete building, with a chimney of the same dimensions as that at Trona. The principal factory building is 86 ft. high, 200 ft. long and 80 ft. wide. The office building houses a modern laboratory, drafting and engineering departments. A warehouse 100 by 300 ft. will soon be constructed, also other necessary buildings with machinery for the preparation and sacking of the company's products. It is expected that the refinery will be operating before Jan. 1, 1917. The plant at Trona is, of course, now in operation. Plans are now being made to increase the size and output of both plants.

Company Reports

The Annual Report of the Vindicator Consolidated Gold Mining Co. for the year 1915 gives as one of the main features for this year the buying of the Golden Cycle Mining Company's property by the Vindicator Company. The latter adjoins the property of the Vindicator and consists of 43.5 acres. This purchase raises the total acreage of the Vindicator from 86 to 130 acres. The various departments of the two properties were consolidated.

In October, 1914, the Vindicator concentrating mill was put into operation, but did not run at full capacity until the first part of 1915. This mill was designed to handle the reject from the ore house and produce a shipping product from material which otherwise would have gone to waste. During the year the mill has handled an average daily tonnage of 250 tons in one shift of eight hours. The average ratio of concentration was 11 to 1. The average percentage of recovery was 55 per cent on an ore running $2 per ton. The milling costs were only $0.20 per ton. A complete return for the value expended was shown after only twelve months' operation.

Much experimenting has been done on the low-grade ore on the dumps averaging $2 per ton or better, and on the low-grade ore in the mines and in the filled stopes. The engineers of the company, after thorough investigation, have recommended the remodeling of the shut-down mill at the Golden Cycle shaft. The flotation process will be used, and the mill is supposed to handle the rejects from the Golden Cycle ore-house and at the same time serve as an experimental station for the ores from all shafts. The capacity of the mill will be 300 tons daily and the cost of changing will be low. A 90 per cent recovery from material running $1 per ton is expected. If this mill works out satisfactorily, after testing all the ores of the property, a modern flotation mill will be erected of not less than a thousand tons daily capacity. Such a mill will cost in the neighborhood of $200,000, where a cyaniding mill of the same capacity would involve an expenditure of $750,000.

During the twelve months' operation of the Vindicator and the ten months during which the Golden Cycle has been producing, there have been mined 218,487 tons of crude ore, which produced 125,397 tons of shipping ore averaging $23.73 per ton. The gross value of the company's shipments amounted to $2,164,668.92 and after deducting treatment charges and freight gave net receipts of $1,718,022.21. Lessees over the same period of time shipped 49,188 tons of ore averaging $16.57 per ton in gold. The gross value of this ore was $815,182.59 and the net receipts amounted to $546,363.55. The royalties received by the company from the lessees amounted to $251,624.09.

The recovery of gross contents was 94 per cent of gold and 90.9 per cent of silver, a decrease of 1 per cent gold and 0.3 per cent silver. The value recovery based on net smelter returns shows 90.3 per cent against 89 per cent for the previous year, or a gain of 1.3 per cent. This is the highest net recovery in the history of the mill. The comparison of these last figures, coupled with the cost of operation, shows the efficiency of the mill. Had the supplies been normal in value an additional reduction of 35 cents per ton could have been made. The increased cost of chemicals is shown in the table.

The total cost to mine and mill the ore and market the products was $7.78 per ton. The metal losses in milling and refining was equal to $1.11 per ton. The profit per ton was $4.77. The average gross value of the ore milled was $13.66.

The **Chicago Section** of the American Institute of Mining Engineers held a dinner meeting at the Chicago Engineers' Club on Friday, Dec. 22. Mr. Alonzo G. Kenyon of the Powdered Coal Engineering and Equipment Co. spoke on "Burning Powdered Coal," and Prof. Harry B. Pulsifer of the Armour Institute of Technology spoke on "Metallurgical Plants About Chicago."

326th Meeting of the Colorado Scientific Society.—This meeting was held on Dec. 2 at the Colorado State Museum. Two papers were presented by Richard C. Hills, the first being "Some Rare Mineral Occurrences" and the second was entitled, "A Denver Made Spinthariscope for Counting the Helium Atoms Given Off by Radio-active Preparations."

The **Perkin Medal** for 1917 will be formally presented to Dr. E. Twitchell at the joint meeting of the New York Sections of the Society of Chemical Industry, American Chemical Society and American Electrochemical Society in the Chemists' Building, New York, on the evening of Jan. 19, 1917.

The Future of the Iron Blast Furnace

By J. E. Johnson, Jr.

That iron is the very basis of our industrial civilization will be admitted by the thoughtful, and many of our greatest supplies of iron ore are being rapidly depleted because of the increased per capita consumption of iron the world over, an increase which is destined to be greater in the future when the races in Asia and Africa increase their consumption of iron. Therefore, the question of a supply for future generations is one vital to the race and is worthy of some consideration here, in view of the fact that the changes in conditions which must come about will affect the economics, and through them the technology of the blast furnace. These conditions of increasing consumption and decreasing reserves have often in the past, particularly about the beginning of this century, been used to create a scare, on the ground that our supplies of usable ore were being so rapidly depleted that their exhaustion would occur within two or three generations. This is a point of view which seems to me preposterous, even leaving out of account the fact that the estimates of the world's iron ore resources, which were used in reaching this conclusion, were subsequently shown to be entirely inadequate. But the corrections which have since been made push into the future, only by a few brief centuries at most, the time at which the exhaustion of these reserves may be expected. It is then not here that our fundamental ground for optimism must be found, but in the fact that as we lower the percentage of iron in the rock, which we agree to call "ore," the quantity of such ore increases at a rate out of all proportion to the decrease in iron content.

In considering the decline in iron content, especially as to the rich ores, we must remember that as there are two oxides of iron containing in the chemically pure conditions different quantities of iron, we must consider them separately. Magnetite Fe_3O_4 contains 72.4 per cent of iron, hematite Fe_2O_3 70 per cent.

There have been magnetites found containing over 70 per cent in iron. In one region, a deposit was found, historically famous for its size and purity combined, in which there were more than 60,000 tons of ore running 70 per cent and over, but this same district contained millions of tons of ore 60 per cent and better, tens of millions of ore of 50 per cent and better, and hundreds of millions of tons containing 30 per cent and better. This, being magnetic ore and free milling, is considered as commercially available ore to-day, and while the same thing is not true commercially of hematites, yet to assume that methods will not be found to concentrate these also is to insult the intelligence of posterity. If we were to drop down to rocks containing 20 per cent of iron, the increase would be still greater.

I believe that this whole matter could be handled accurately upon the basis of the probability curve, but I am not mathematician enough to do it, nor have I been able to obtain the assistance of a mathematician who could, but such tentative figures as I have, obtained from an authoritative source, indicate that for every million tons of iron ore from 60 to 65 per cent iron content there are 85,000,000 tons of 30 to 35 per cent, and the increase is even more rapid as we drop below this point.

It is obvious then that we shall never run out of iron-bearing material—we shall simply use leaner and leaner material as time goes on.

This process has already proceeded further than we realize, unless we stop to look up the records of the past. A good standard of comparison is the fact that when my father made an examination of the famous Chapin mine in 1891, just a quarter of a century ago, he found them throwing 56 per cent material over the dump as "rock."

The direct result of further change in the same direction will be to increase the cost of pig iron for the reasons elaborated in earlier articles, and this fact must be frankly faced. But we have seen increases in price of pig iron many times greater than that which would result from reducing the iron in the ore from 55 to 30 per cent, but neither the consumption of iron nor civilization was checked by these conditions; if one took only the superficial view they would appear to have been accelerated, and it is, therefore, reasonable to assume that if this condition of high prices becomes chronic for industrial reasons, instead of being spasmodic for commercial reasons, civilization would scarcely feel the difference, especially as it is a change which will take place with exceeding deliberation.

A change, such as that indicated above, would increase our resources in ore to an extent which staggers the imagination, and there is no reason to doubt that the tendency to increased cost, due to the use of leaner ores, would be met by technical and industrial improvements which would minimize if they did not wipe out the increase.

The same thing has happened in other industries. Gold ore worth $10 per ton was probably not commercial fifty years ago; to-day gold is being extracted at a profit from ores which contain values of only $1 per ton. Similarly the copper ores of fifty years ago were rich. In the early days of Calumet & Hecla the ore ran 3 per cent in copper and sometimes 4 per cent. It was sweetened by huge masses of native copper of such great size that in those early days of little or no equipment great difficulties were encountered in cutting them small enough to be brought out of the mine. Copper in that day commanded a price of 20 to 30 cents a pound; to-day mines are extracting copper from ore containing 1½ per cent and less of the metal, and they could sell it, if they wished, at 8 cents a pound.

If nature has been more generous to the iron industry and endowed it with extensive supplies of ore, capable of immediate use in the furnace without beneficiation, that is no sign that the iron industry and civilization with it will be extinguished by the exhaustion of these deposits, and the consequent necessity of descending to ores containing only a fraction as much metal.

Advances are to be expected along both industrial and technical lines. Much of the value of the high-grade ores of to-day is made up of two elements—a rarity value, namely, the royalty paid to the owner because of the exclusive ownership of existing deposits, and a transportation value due to the necessity of bringing these relatively rare rich ores to the point of consumption.

If the day ever comes when we drop down, for instance, to 30 per cent ores, the bodies of these are so vast that exclusive ownership will be almost impossible, and the royalty value will greatly decline or fade away, while, owing also to the relative numerousness of such bodies of material, the chances are that they will be found much closer to the points of consumption than the rich but rare bodies of to-day. This, then, will tend to reduce the transportation values of these ores, or at least will tend to offset the increased cost of transportation, due to the greater number of tons required per ton of iron.

On the technical side, improvements may reasonably be expected along four lines—mining, ore dressing, by-products, and the furnace itself.

Mining

Cheaper mining is to be expected because we shall be able to choose among the most favorably located of the great deposits of low-grade material, and for centuries probably nothing but open pit work will be done upon them, which will mean a minimum of cost.

Ore Dressing

In regard to ore dressing, the metallurgy of iron is far behind any other, partly because of nature's hitherto bountiful supply of ores directly available, and partly because the blast furnace, being a willing horse, has often been made to carry an unfair burden. Its proper task is the reduction of iron to the metallic state from its oxide; it has also often been made to serve as an ore dressing apparatus and separate the iron from the gangue as well, for the good commercial reason that it furnished the cheapest way to do it, if other conditions were right. Most of the science of ore dressing for the iron industry, therefore, lies in the future, and there, as far as this work is concerned, we must leave it, since it is impossible to foretell the lines of development which will follow, and they would be out of place here, if we knew them.

By-Products

It is only within the last ten or twelve years that we have been accustomed to consider the by-products from the furnace as having any value, but leaving aside for the present the question of the gas, we are coming to an increased realization of the importance of the slag in making cement. As concrete construction grows in relative importance to steel, as well as in an absolute importance, and as the quantity of slag per ton of iron increases, which it necessarily must from the use of leaner ores, we must look for a wider and wider application of this slag to the production of cement. We may even hope that the present method of manufacture, which theoretically at least seems very crude, will in time to come be improved, revolutionized perhaps, so that what one furnaceman has been accused of dreaming—tapping iron out of the iron notch and cement out of the cinder notch of the blast furnace—may almost come to pass.

If the cinder can be converted into cement with a profit which will only pay for handling the gangue of the ore and the limestone to flux it, the furnace of the future will obviously be relieved of a heavy part of its increased burden.

The Blast Furnace

Turning now to the furnace itself, whatever we say or suggest must be taken in the light of prophecy and subject to all the errors and discounts to which all prophecy is subject, because if there were means whereby we could increase the economy of the furnace when running on lean ores beyond the present possibilities, obviously it would not be a matter for the future, but would be in process of being done to-day.

Turning back to the article on commercial considerations, it is easy to believe that the furnace of the future will feel no particular pressure on account of fuel consumption until the latter has risen beyond the point at which the furnace gases will supply all the heat and power requirements of the associated steel mill, except, of course, at isolated merchant furnaces having no such market for their power. The question as to how we shall reduce the fuel consumption, when this point is reached, is the ultimate question which the industry must answer, and though it is a long way in the future for us, there are visible, even to-day, means whereby it may be done. Of course, the possibilities of hotter blast and all the other lines along which present developments are progressing will have been pretty well exhausted by that time; we must look for a more radical solution.

This, in my judgment, is to be found in the modern industry of separating the oxygen from the nitrogen of the atmosphere by purely physical means, and using this instead of air to blow the furnaces of the future. This idea is not novel in the industry. Experiments were made in the direction of enriching the oxygen content of the blast in Belgium a year or two previous to the breaking out of the Great War, but no important results were obtained, or at least those published were unimportant because the degree of enrichment was too small to produce any marked change. Some American furnacemen have taken the ground that no gain was to be expected on theoretical or practical grounds. If that contention be correct, the fundamental principles of the blast furnace, as set forth in a former article of this serial are wrong, the explanations of known phenomena made on the basis of these principles are incorrect, and there is scarcely an article in the serial which can be accepted without the most drastic revision. If, on the other hand, the thermal principles set forth are correct, then we may proceed to show quantitatively the effect which oxygen in different proportions would have upon the thermal relations in the hearth and bosh of the furnace.

Fig. 1 is a diagram giving the quantities of hearth heat obtainable per pound of coke (counting 0.85 lb. of fixed carbon burned in the hearth) with dry air blast at 1000 deg. Fahr., and with a mixture of equal weights of oxygen and nitrogen at atmospheric temperature. This diagram shows that at low critical temperature there is but little advantage in the oxygen blast, but as the critical temperature rises the advantage increases from a few per cent to several hundred per cent.

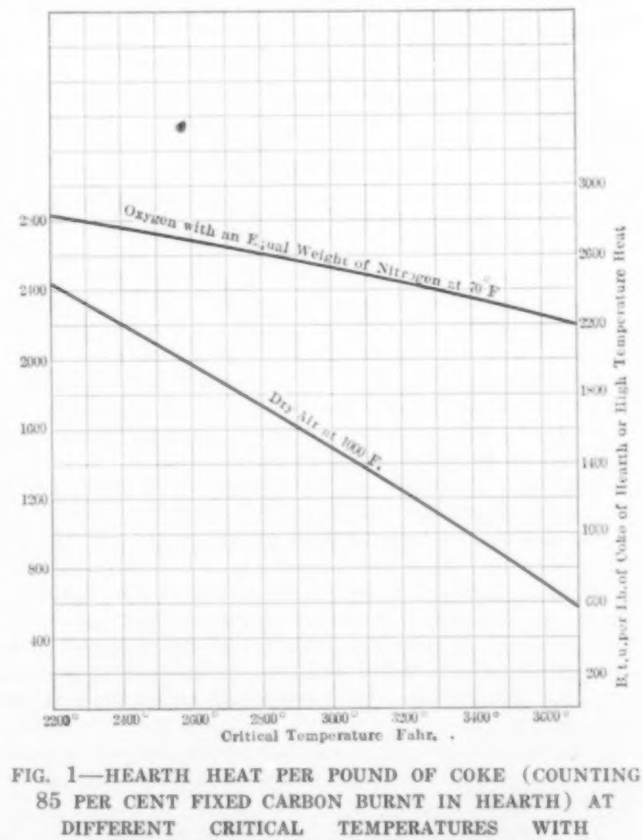


FIG. 1—HEARTH HEAT PER POUND OF COKE (COUNTING 85 PER CENT FIXED CARBON BURNT IN HEARTH) AT DIFFERENT CRITICAL TEMPERATURES WITH BLAST OF DRY AIR AT 1000 DEG. FAHR., AND WITH BLAST OF EQUAL WEIGHTS OF OXYGEN AND NITROGEN

The study of this diagram enables us to see what changes may be made in the thermal operation of the furnace by the use of oxygen blast.

There are many who will doubt the possibility of obtaining the supply of oxygen which would be required for such a use, but the process of separating air into its component oxygen and nitrogen on an industrial scale by distillation from liquid air is now in actual operation at Niagara Falls, separating many thousand cubic feet of air per hour.

Those who remember the ridiculous claims made for liquid air some eighteen years ago, and their subsequent utter collapse, are inclined to deny the commercia' possibility of that operation, on theoretical grounds, but this is not correct. The theoretical power for effecting the separation, figured on the basis outlined by Ostwald, the great apostle of physical chemistry, amounts to only 1 hp. per 6 cu. ft. of oxygen produced per minute. A modern 500-ton blast furnace requires 45,000 cu. ft. of air or 9000 cu. ft. of oxygen per minute, which would require, on the theoreical basis, 1500 hp. for its production, as against the 2500 hp. now necessary to blow the furnace.

The best performance of any actual air separating operation to-day requires about seven times the theoretical amount of power, so we are still far from being able to replace existing methods on the power basis. Processes are under development, however, which promise to reduce this power requirement by one-half or two-thirds; in other words, we hope to produce oxygen at an efficiency of 50 per cent, based on theoretical power, and there is no fundamental reason why we should not do so. Even this, it will be said, is no improvement over present conditions, and on the power basis alone that would be true. But this question cannot be decided on the power basis alone, for two reasons:

1. The heat consumption of the blast under present blast furnace conditions is not limited to power alone.

2. The result in the furnace itself must be considered.

In regard to the first point, it must be remembered that blast must not only be compressed, but it must be heated, and this operation requires about four times the heat required to supply power for compression; then there is the heating equipment, which costs as much as the power plant, all of which would be saved by the use of oxygen. This brings us to the second point, the effect of oxygen in the furnace itself.

It will be seen that for the average condition, 2750 deg. critical temperature, the hearth heat with the ordinary hot blast is about 1800 B.t.u. per pound of coke, while with the 50 per cent oxygen blast, it is 2625 B.t.u.; in other words, we can raise the amount of hearth heat obtainable from a given amount of coke nearly 50 per cent by the use of a blast containing one-half oxygen. If the critical temperature be higher the advantage is still greater.

Let us remember that it has been shown in the article on thermal principles that the rapid increase in fuel consumption with leaner ores comes principally from the increased slag to be melted, and the volume of slag increases with enormous rapidity as the percentage of iron in the ore declines. The average Lake Superior ore of 52 per cent iron produces about half a ton of slag per ton of iron. Ore of 38 per cent iron and 38 per cent silica produces about 2¼ tons of slag, which at 0.4 of a ton of coke per ton of slag means an increase of 0.7 of a ton in coke. On the same basis, an ore containing about 25 per cent iron Fe, 48 per cent SiO_2 and 15 per cent Al_2O_3, would produce 5 tons of slag per ton of iron which, on the basis of 0.4 of a ton of coke, would demand an increase of almost 2 tons in the coke required to make a ton of iron, working under present conditions. If the total coke per ton of iron became 3 tons with ordinary hot blast, on the basis of the hearth heat developed, it would drop back to 2 tons with half oxygen blast.

But we must consider the development of shaft heat as well as hearth heat. With lean ore and half oxygen blast, we should require more than under present conditions, for two reasons:

1. The larger quantity of slag forming materials to be heated to the critical temperature in the shaft.

2. The smaller quantity of nitrogen present to carry heat from the hearth up into the shaft.

But we have seen in discussing thermal principles that a reduction of the amount of fuel required to smelt a given weight of iron automatically increases the amount of heat available in the shaft, because a larger proportion of the CO present at the top of the bosh is oxidized to CO_2 by the oxygen of the ore, with a correspondingly greater development of shaft heat.

We have seen further that solution loss is one of the prime causes of insufficient shaft heat development, as well as of insufficient hearth heat development.

In order to eliminate this loss more or less completely, especially in the upper regions of the furnace, where the concentration of CO_2 and the solvent action are the greatest, I have suggested a furnace in which the fuel should be fed down through the center of the furnace, and for some distance down kept from contact with the ore, while the gas was made to travel the last portion of its journey through the ore alone, thereby eliminating its alternating contact with ore and fuel, the prime cause of solution loss with the present process.

This design is shown by Figs. 2 and 3. The water-cooled steel mantle with a fluted bottom is supported from the top of the furnace, its top is sealed and no escape of gas permitted therefrom. The fluting is intended to promote a quick and intimate mixture of the ore and fuel in the lower regions of the furnace.

It is hardly necessary to say that this scheme has never been tried, nor has the use of oxygen blast in any percentage calculated to produce revolutionary results. The whole idea must, therefore, be counted as a dream, for the present, but in considering the possibilities of the future, as we now are, it is well to remember that incredulity has discounted the wisdom of the race many times oftener than credulity, and allowing that the supply of oxygen can be obtained, which is a possibility now almost appearing within sight over the horizon, there is nothing in the principles of furnace operation, as we know them, to cast doubt upon the possibilities of such a design.

Objections will naturally occur to the thoughtful, but they are more apparent than real. Perhaps the first would be the difficulty of maintaining the furnace structure in the intense heat produced by the combustion of carbon in oxygen, but the answer to this is easy. We do not desire or intend to produce any higher temperature than we now have. We propose merely to generate more high temperature heat, and then give it enough more work to do to bring the temperature back to where it is to-day, always remembering that, in the broad sense, the temperature prevailing in any zone of combustion is proportional to the amount of heat developed, divided by the thermal capacity of the materials present.

Another objection will be that the reduced area available for the passage of the gas will not permit the furnace to be blown at any speed worthy of consideration. Here, again, appearances are in error, because a blast containing one-half oxygen has a total volume less than one-half that of air containing the same quantity of oxygen. If by the use of oxygen we reduce the fuel

consumption to two-thirds, the gas per ton of ore becomes approximately one-half what it would be with atmospheric blast under the same conditions, and this can, therefore, pass out through an area one-third as large.

On the other hand, such a process has some advantage over the existing furnace in other respects besides fuel consumption. First is the production as a by-product of a large quantity of pure nitrogen, and it is reasonable to believe that this would, to a large extent, come into use for fixation purposes. Second, because the fuel does not require to be penetrated by the gas column, but should be made as impervious as possible to it; a part of the fuel could be charged as coal, not coke, and this would save a corresponding proportion of the coking cost, and the investment for ovens.

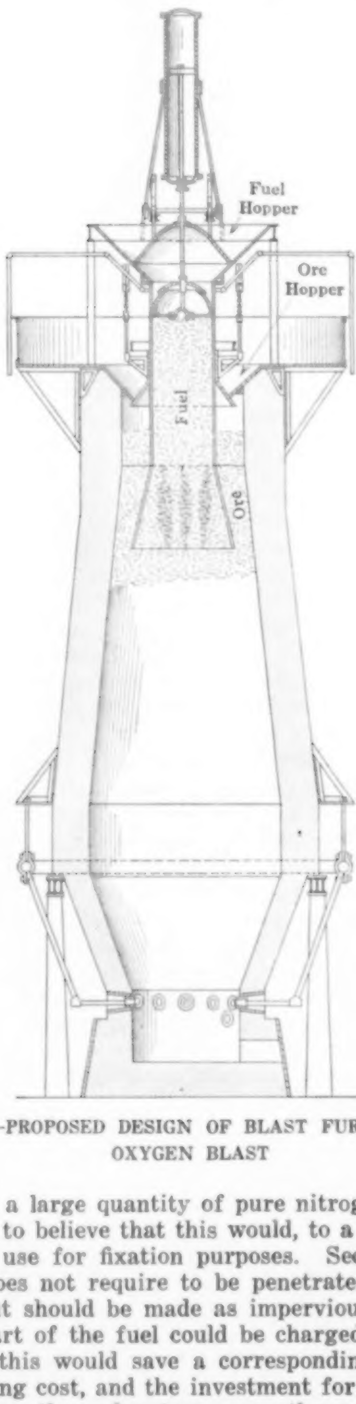


FIG. 2—PROPOSED DESIGN OF BLAST FURNACE FOR OXYGEN BLAST

There are other advantages over the present process if we could make this dream true. Not the least, perhaps, would be the elimination of the stoves and the consumption of gas required to heat them. The furnace would not need to have so large a volume on account of the much smaller volume of gas passing through it and the correspondingly greater concentration of the latter in active components. The furnace gas would be richer on account of the elimination of the nitrogen, in spite of being more diluted with CO_2.

Of course, we do not know that the blast furnace, the oldest industrial apparatus still in the service of man, will survive the changes which the future is to bring. Other methods of smelting iron have been proposed, and while they have in the main failed, a careful study of the thermal principles will show that they need not necessarily fail on theoretical grounds; but if the blast furnace remains our best, or even our only servant for the conversion of nature's stores of iron to our use, it is evident that there are long strides in sight which it may take, and that when these are taken it will be possible for us to use commercially as ores what we should now dismiss as rock, and that the supply of raw material thereby placed at our disposal is so enormously enhanced that we can more easily foresee the failure of civilization from other causes than from the failure of its supply of iron and steel.

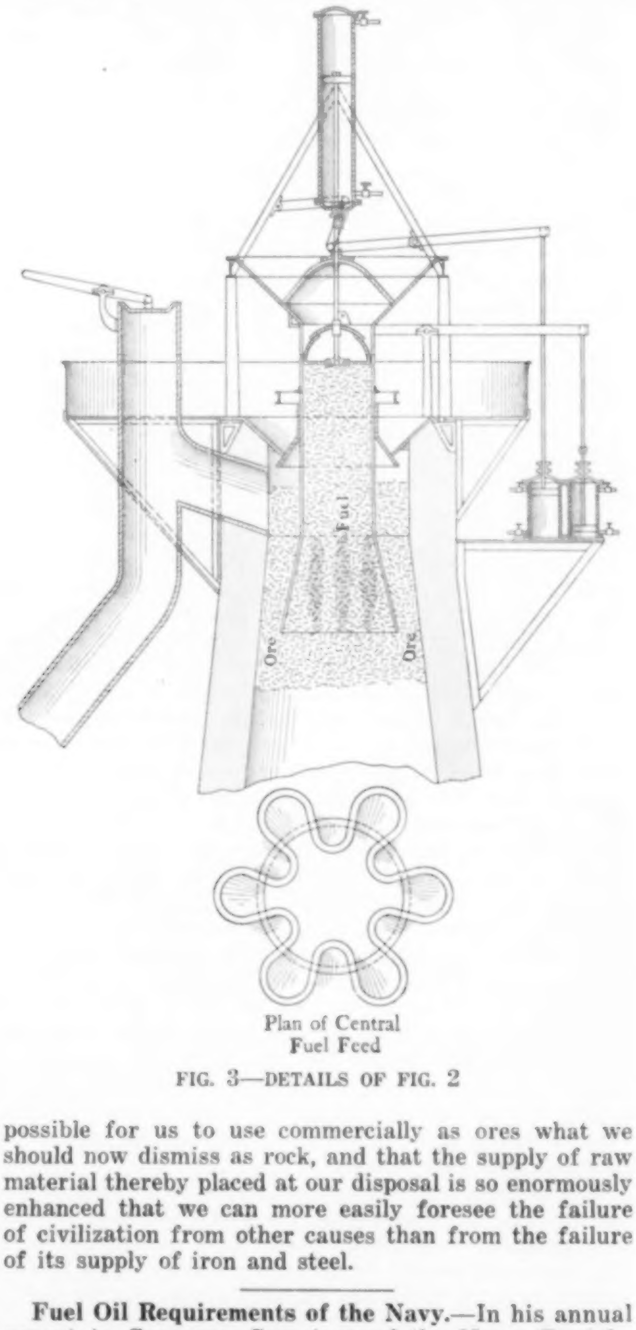


FIG. 3—DETAILS OF FIG. 2

Fuel Oil Requirements of the Navy.—In his annual report to Congress, Secretary of the Navy, Daniels, points out that when the three-year program already authorized by Congress is completed the Navy will require 6,721,000 barrels of fuel oil annually during peace. All new ships are oil burners and the navy has taken steps to acquire oil lands to be held in reserve. This future supply is threatened by legislation which would benefit others and the Secretary makes a plea for the upholding of public interest against private ownership.

Supreme Court Decision in Hyde Flotation Suit

The complete text of the decision of the Supreme Court, written by Judge Clarke, in the suit of Minerals Separation Ltd. and Minerals Separation American Syndicate, Ltd. versus James M. Hyde is as follows:

In this suit the complainants, the first named as the owner and the other as general licensee, claim an infringement of the United States letters patent No. 835,120, issued on the 6th day of November, 1906, to Henry Livingstone Sulman, Hugh Fitzalis Kirkpatrick-Picard, and John Ballot. The usual injunction, accounting and damages are prayed for. The District Court sustained the patent as to claims numbered 1, 2, 3, 5, 6, 7, 9, 10, 11, and 12; found that the defendant had infringed each of these claims, and granted the prayer of the petition. The Circuit Court of Appeals for the Ninth Circuit reversed the decree of the District Court and remanded the case with instructions to dismiss the bill. The case is here on writ of certiorari to review that decision.

As stated in the specification, the claimed discovery of the patent in the suit relates "to improvements in the process for the concentration of ores, the object being to separate metalliferous matter from gangue by means of oils, fatty acids, of other substances which have a preferential affinity for such metalliferous matter over gangue."

The answer denies all of the allegations of the bill and avers that in twenty-five designated United States and five British patents the process described in suit was "fully and clearly described and claimed," and it also avers that the claimed discovery was invented, known and used by many persons long prior to the time when the application was made for the patent in suit. Notwithstanding this elaboration of denial counsel for the defendant in the summarized conclusion to their brief rely upon only five of the many patents referred to as showing that the patent in suit was anticipated and is therefore invalid for want of novelty and invention, viz: Everson (1886), Froment (Italy, 1902; Great Britain, 1903), Glagner (1903), Schwartz (applied for April 19, 1905, issued Dec. 19, 1905), and Kirby (applied for Oct. 17, 1903, issued Dec. 18, 1906). And the defendant, a man obviously experienced in the subject, says that, in his opinion, the whole basis of flotation concentration was disclosed in the Everson United States patent No. 348,157 and in the Froment British patent.

It is clear that in the prior art, as it is developed in this record, it was well known that oil and oily substances had a selective affinity or attraction for, and would unite mechanically with, the minute particles of metal and metallic compounds found in crushed or powdered ores, but would not so unite with the quartz, or rocky non-metallic material, called "gangue." Haynes' British patent (1860), and United States patents, Everson (1885), Bobson (1897) and Elmore (1901). It was also well known that this selective property of oils and oily substances was increased when applied to some ores by the addition of a small amount of acid to the ore and water used in process of concentration. United States patents Everson (1885), Elmore (1901) and Cattermole (1904).

Prior to the date of the patent in suit a number of patents had been granted in this and other countries for processes aiming to make practical use of this property of oil and of oil mixed with acid in the treatment of ores, all of which, speaking broadly, consisted in mixing finely crushed or powdered ore with water and oil, sometimes with acid added, and then in variously treating the mass—"the pulp"—thus formed so as to separate the oil, when it becomes impregnated or loaded with the metal and metal-bearing particles, from the valueless gangue. From the resulting concentrate the metals were recovered in various ways.

The processes of this general character described in the prior patents may be roughly divided into two classes. The process in the patents of the first class is called in the record the "Surface Flotation Process" and it depends for its usefulness on the oil used being sufficient to collect and hold in mechanical suspension of the small particles of metal and metalliferous compounds and by its buoyancy to carry them to the surface of the mixture of ore, water and oil, thus making it possible, by methods familiar to persons skilled in the art, to float off the concentrate thus obtained into any desired receptacle. The waste material, or gangue, not being affected by the oil and being heavier than water sinks to the bottom of the containing vessel and may be disposed of as desired.

The process of the other class, called in the record the "Metal Sinking Process," reverses the action of the Surface Flotation Process and is illustrated by the Cattermole U. S. patent, No. 777,273, in which oil is used to the extent of 4 per cent to 6 per cent to 10 per cent of the weight of the metalliferous mineral matter, depending on the character of the ore, for the purpose of agglomerating the oil-coated concentrate into granules heavier than water, so that they will sink to the bottom of the containing vessel, permitting the gangue to be carried away by an upward flowing stream of water.

The process of the patent in suit, as described and practised, consists in the use of an amount of oil which is "critical" and minute as compared with the amount used in prior processes "amounting to a fraction of 1 per cent of the ore," and in so impregnating with air the mass of ore and water used, by agitation—"by beating the air into the mass"—as to cause to rise to the surface of the mass, or pulp, a froth, peculiarly coherent and persistent in character, which is composed of air bubbles with only a trace of oil in them, which carry in mechanical suspension a very high percentage of the metal and metalliferous particles of ore which were contained in the mass of crushed ore subjected to treatment. This froth can be removed and the metal recovered by processes with which the patent is not concerned.

It is obvious that the process of the patent in suit, as we have described it, is not of the Metal Sinking class, and while it may, in terms, be described as a Surface Flotation Process, yet it differs so essentially from all prior processes in its character, in its simplicity of operation and in the resulting concentrate, that we are persuaded that it constitutes a new and patentable discovery.

The prior processes which we have described required the use of so much oil that they were too expensive to be used on lean ores, to which they were intended to have their chief application, and the efforts of investigators for several years prior to the discovery of the process in suit had been directed to the search for a means or method of reducing the amount of oil used, and it is clear from the record that approach was being made, slowly, but more and more nearly to the result which was reached by the patentees of the process in suit in March, 1905. The Froment Great Britain patent (1903) and the Kirby United States patent (applied for in 1903 and granted in 1906) are especially suggestive of the advance which was being made toward the desired result, but the Froment process was little more than a laboratory experiment and has never proved of value in practice, and the Kirby process, though approaching in some respects more nearly to the end attained by the process of the patent in suit, found its preferred application in the use of an amount of oil solution equal to one-fourth to three-fourths in weight of the ore treated, which was prohibitive in cost.

Into this field of investigation at this stage of its development came the patentees of the patent in suit. They were experienced metallurgists of London, of inventive genius and with financial resources, and they entered upon an investigation of the processes of oil concentration of ores which was continued through several years, and consisted of a very extended series of experiments in which the quantities of oil, of water and of acid used and the extent and character of the agitation of the mass under treatment resorted to, were varied to an almost unparalleled extent as to each factor and the results were carefully tabulated and interpreted. It was while pursuing a comprehensive investigation of this character, having, as the evidence shows, the special purpose in mind at the time to trace the effect on the results of the process of a reduction to the vanishing point of the quantity of oil used, that the discovery embodied in the patent in suit was made.

The experimenters were working on the Cattermole "Metal Sinking Process" as a basis when it was discovered that the granulation on which the process depended practically ceased when the oleic acid (oil) was reduced to about 5 per cent "on the ore." It was observed, however, that, as the amount of oleic acid was further reduced and the granulation diminished, there was an increase in the amount of "float froth," which collected on the surface of the mass and that the production of this froth reached its maximum when about 1 per cent or slightly less "on the ore" of oleic acid was used. This froth, on collection, was found to consist of air bubbles modified by the presence of the minute amount of oil used and holding in mechanical suspension between 70 per cent and 80 per cent of the total mineral content of the mass treated. It was promptly recognized by the patentees that this froth was not due to the liberation of gas in the mass treated by the action of the dilute acid used, and its formation was at once attributed in large part to the presence of the air introduced into the mixture by the agitation which had been resorted to to mix the oil with the particles of crushed ore, which air, in bubbles, attached itself to the mineral particles, slightly coated as they

were with what was necessarily an infinitesimal amount of oil, and floated them to the surface. The extent of the agitation of the mass had been increased as the experiments proceeded until the "series of Gabbett mixers, fitted with the usual baffles, were speeded at from 1000 to 1100 revolutions per minute."

A careful consideration of the record in this case convinces us that the facts with respect to the process of the patent in suit are not overstated by the plaintiffs' witness, Adolph Liebmann, an expert of learning and experience, when he says in substance:

"The present invention differs essentially from all previous results. It is true that oil is one of the substances, but it is used in quantities much smaller than was ever heard of, and it produces a result never obtained before. The minerals are obtained in a froth of a peculiar character, consisting of air bubbles which in their covering film have the minerals embedded in such manner that they form a complete surface all over the bubbles. A remarkable fact with regard to this froth is that, although the very light and easily destructible air bubbles are covered with a heavy mineral, yet the froth is stable and utterly different from any froth known before, being so permanent in character that I have personally seen it stand for twenty-four hours without any change having taken place. The simplicity of the operation, as compared with the prior attempts, is startling. All that has to be done is to add a minute quantity of oil to the pulp to which acid may or may not be added, agitate for from two and one-half to ten minutes and then after a few seconds collect from the surface the froth which will contain a large percentage of the minerals present in the ore."

It is not necessary for us to go into a detailed examination of the process in suit to distinguish it from the processes of the patents relied on as anticipations, convinced as we are that the small amount of oil used makes it impossible that the lifting force which separates the metallic particles of the pulp from the other substances of it is not to be found principally in the buoyancy of the oil used, as was the case in prior processes, but that this force is to be found chiefly in the buoyancy of the air bubbles introduced into the mixture by an agitation greater than and different from that which had been resorted to before and that this advance on the prior art and the resulting froth concentrate so different from the product of other processes make of it a patentable discovery as new and original as it has proved useful and economical.

It results without more discussion, that we fully agree with the decision of the House of Lords, arrived at upon a different record and with different witnesses, but when dealing with the equivalent of the patent in suit, in Minerals Separation, Limited, v. British Air Concentration Syndicate, Limited, 27 R. P. C. 33. In this decision Lord Shaw, speaking for the court and distinguishing the process there in suit especially from the Elmore oil flotation process which had gone before but which was typical of the then prior art said: "They (the patentees of the Agitation Froth Process of the patent in suit) are not promoting a method of separation which had before been described, but they are engaged upon a new method of separation. Instead of relying upon the lesser specific gravity of oil in bulk they rely upon the production of a froth by means of an agitation which not only assists the process of the minute quantities of oil reaching the minute particles of metal, but forms a multitude of air cells, the buoyancy of which air cells, forming around single particles of the metal, floats them to the surface of the liquid."

And Lord Atkinson said: "In the process this mysterious affinity of oil for the metallic particles of the ore is availed of, yet the oil is used in such relatively infinitesimal quantities that the metallic particles are only coated with a thin film of it, and the lifting force is found not in the natural buoyancy of the mass of added oil, but in the buoyancy of air bubbles, which, introduced into the mixture by the more or less violent agitation of it, envelop or become attached to, the thinly oiled metallic particles, and raise them to the surface, where they are maintained by what is styled the surface tension of the water."

The record shows not only that the process in suit was promptly considered by the patentees as an original and important discovery, but that it was immediately generally accepted as so great an advance over any process known before that, without puffing or other business exploitation, it promptly came into extensive use for the concentration of ores in most, if not all, of the principal mining countries of the world, notably in the United States, Australia, Sweden, Chile and Cuba, and that, because of its economy and simplicity, it has largely replaced all earlier processes. This, of itself, is persuasive evidence of that invention which it is the purpose of the patent laws to reward and protect. Diamond Rubber Co. v. Consolidated Tire Co., 220 U. S. 428; Carnegie Steel Co. v. Cambria Iron Co., 185 U. S. 403, 429, 430; The Barbed Wire Patent, 143 U. S. 275; Smith v. Goodyear Dental Vulcanite Co., 93 U. S. 486.

The claim that the patentees of the patent in suit are not the original discoverers of the process patented because an employee of theirs happened to make the analysis and observations which resulted immediately in the discovery, cannot be allowed. The record shows very clearly that the patentee planned the experiments in progress when the discovery was made; that they directed the investigations day by day, conducting them in large part personally and that they interpreted the results. Agawam Company v. Jordan, 7 Wall, 583-603, rules this claim against the defendant.

Equally untenable is the claim that the patent is invalid for the reason that the evidence shows that when different ores are treated, preliminary tests must be made to determine the amount of oil and the extent of agitation necessary in order to obtain the best results. Such variation of treatment must be within the scope of the claims, and the certainty which the law requires in patents is not greater than is reasonable, having regard to their subject matter. The composition of ores varies infinitely, each one presenting its special problem, and it is obviously impossible to specify in a patent the precise treatment which would be most successful and economical in each case. The process is one dealing with a large class of substances and the range of treatment within the terms of the claims, while leaving something to the skill of persons applying the invention, is clearly sufficiently definite to guide those skilled in the art to its successful application, as the evidence abundantly shows. This satisfies the law. Mowry v. Whitney, 14 Wall. 620; Ives v. Hamilton, 92 U. S. 426, and Carnegie Steel Co. v. Cambria Iron Co., 185 U. S. 403, 436, 437.

The evidence of infringement is clear.

While we thus find in favor of the validity of the patent, we cannot agree with the District Court in regarding it valid as to all of the claims in suit. As we have pointed out in this opinion, there were many investigators at work in this field to which the process in suit relates when the patentees came into it, and it was while engaged in study of prior kindred processes that their discovery was made. While the evidence in the case makes it clear that they discovered the final step which converted experiment into solution, "turned failure into success" (The Barbed Wire Patent, 143 U. S. 275), yet the investigations preceding were so informing that this final step was not a long one and the patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as "critical proportions" "amounting to a fraction of 1 per cent on the ore," and therefore the decree of this court will be that the patent is valid as to claims Nos. 1, 2, 3, 5, 6, 7 and 12, and that the defendant infringed these claims, but that it is invalid as to claims 9, 10 and 11. Claims No. 4, 8 and 13 were not considered in the decree of the two lower courts and are not in issue in this proceeding.

The decision of the Circuit Court of Appeals will be reversed, and the decision of the District Court, modified to conform to the conclusions expressed in this opinion, will be affirmed.

Bureau of Standards to Study Refractories.—The Bureau of Standards has begun an investigation of clay refractories in co-operation with the American Refractories Manufacturers' Association and the American Gas Institute. The bureau also has begun preliminary work on another investigation dealing with a phase of the same industry, using a dolomite in certain metallurgical furnaces as a refractory. Usually the burned dolomite is placed directly in position in the furnace with tar or some other combustible material as a binder. Where the lining was of such a nature that it had to be made of brick, magnesite brick was used. The price of magnesite brick, however, has advanced to such a degree that the use of this material has become almost prohibitive. It has been suggested at various times that dolomite might be burned in such a manner, or with the addition of such impurities that the lime present in it would not slake, except after an extended period, making it possible to produce a brick of this material which would replace the magnesite brick. The bureau by its investigation will determine the possibility of producing such a burned dolomite.

Current Efficiency in Copper Refining

By Lawrence Addicks

Current efficiency in an electrolytic operation is the ratio between the weight of product obtained per ampere hour and that called for by Faraday's law, for the current used in the desired reaction. It has therefore much to do with the cost of operations, but in this connection it must be considered jointly with the voltage factor; for example, the series system in copper refining operates at a lower current efficiency than the multiple and yet yields a greater weight of cathode per kilowatt-hour expended in the cell. For any given case, however, it is desirable to obtain as high a current efficiency as may be consistent with the cost of securing it, and it is our purpose to examine this question in its bearing to the multiple system of electrolytic copper refining.

The percentage which we obtain by dividing the weight in grams of cathode per ampere hour by 1.186 is less than 100 because part of the current performs no electrolytic operation on account of leakage or short circuits between electrodes, part is involved in reactions not desired and a portion of the cathode itself is redissolved chemically. It is even possible to obtain apparent efficiencies above 100 per cent under certain conditions.

In order to secure an exact correspondence with Faraday's law various niceties of operation must be observed and a great deal of study in this direction has been applied by those interested in voltmeter measurements. It is quite possible, however, with care and dismissal of questions of labor cost, to obtain a working efficiency on a large scale of 99 per cent. Commercially it is found, however, that about 92 per cent is as high a figure as it is advisable to insist upon and at some plants 90 per cent or even 88 per cent is considered satisfactory. Current density has a direct bearing on the problem in that a high density greatly increases the difficulty in preventing short circuits between the electrodes.

The various factors involved may be classified as follows:

A. Current leakage:
- a. To ground.
- b. Through electrolyte.
- c. Between electrodes.

B. Reaction:
- a. Deposition of impurities.
- b. Gassing.
- c. Valence.

C. Cathode shrinkage:
- a. Sulphatizing.
- b. Ferric salts.
- c. Nodules, etc.

A. Current Leakage

(*a*) *To Ground.*—The insulation resistance of the circuit from the ground may be determined by noting the reading of a high-resistance voltmeter when connected from either switch terminal on the live circuit to the ground by a simple application of Ohm's law. The current flowing through the voltmeter is obtained by dividing its reading by its known resistance; the total resistance in the leakage circuit is obtained by dividing the known line voltage by this current; the insulation resistance is found by subtracting the known voltmeter resistance.

It is evident that the resistance found in this way is a measure of the obstacles in the path of the current from the ground back through improper channels to the other leg of the circuit, and that by opening the main circuit at predetermined points and taking repeated measurements a leakage map could be worked out. This, however, should not be necessary, as while the insulation resistance of an electrolytic circuit will always be low—a usual value is five ohms—the actual loss of effective current from this source is a minor matter in any plant where the foundation piers are properly capped with glass plates and tank leaks kept from resulting in sulphate crystals climbing around promiscuously.

If we assume that a circuit has a total resistance of five ohms from one side to the other through the ground and that the line voltage is 150, this leakage will be but 30 amp. If the main current is 10,000 amp. and the leakage uniformly distributed so that it robbed an average of but half the tanks, the percentage loss would be but 0.15 per cent.

(*b*) *Through Electrolyte.*—There are three ways of determining the loss of effective current due to improper shunt circuits through the circulation system: by direct measurement, by Ohm's law calculations and by Faraday's law calculations.

The direct method consists of placing carefully calibrated ammeters at various points in the circuit and comparing their readings, which would be identical except for losses under (*a*) and (*b*). Considerable care is required to avoid errors in measurement as thermoelectric effects may creep into the temporary shunt connections and magnetic errors, due to strong stray field, may distort the meter readings even when the instruments are protected by iron cases. An unprotected portable instrument may even be permanently thrown out of adjustment by exposure of its permanent magnets to the action of the stray field which exists within a couple of feet of a conductor carrying 10,000 amp.

Another method is to open the circuit in the center and note how many amperes are recorded by the powerhouse ammeter when full voltage is applied. This is not fair in that the voltage distribution throughout the circuit is not normal.

It will generally be found that the tanks at the far end of a circuit receive 3 or 4 per cent less than the switchboard current.

Ohm's law calculations may be made upon the liquid columns of electrolyte, as we know the resistance per cubic inch of the liquor, its physical dimensions and the voltages operating. Where the voltages are sufficiently low the lead pipe cannot act as a conductor, as when the current leaves it there must be sufficient voltage to decompose water. When such voltages occur sections of hard rubber or of rubber hose are employed to break the continuity of the metal path. It is also possible to take fall of potential readings along a lead pipe and figure the current flowing therein by Ohm's law and the specific resistance of hard lead.

Finally, we know that wherever the current enters the piping system it must deposit Faraday's equivalent of copper. This is of great practical assistance, as while it gives no information regarding the current flowing in the liquid itself, it does bring to daily attention any abnormal participation of the conduit system, and the accumulation of copper trees demands early attention to avoid stopping up the pipes.

The coating of lead sulphate which covers all tank linings and pipes exposed to the action of the electrolyte acts as an insulating paint of much value, as shown by the low efficiencies always obtained in starting up a new installation of bright tanks. A final insulating joint is usually effected where the electrolyte leaves a tank by allowing it to fall freely into the launder without a containing pipe for some inches.

Altogether ample means exist for measuring and controlling this source of loss.

(*c*) *Between Electrodes*.—The direct touching of anode and cathode is the most usual cause of poor efficiency. This condition can be brought about by the electrodes being carelessly spaced in the tank, by the curling of starting sheets, by falling of anode scrap, by omission of electrode insulators, by electrodes displaced sideways so as to touch the lead lining of the tank, by "treeing" of the cathode deposit, by the accumulation of an excessive quantity of slimes in the bottom of the tank or by the careless leaving of tools lying on top of the electrodes.

It is obvious that with the exception of "treeing" and falling anode scrap these causes may be removed in proportion to the amount of labor and inspection applied. Treeing involves the control of the cathode deposit by the choice of a suitable cathode age for the current density employed, adequate circulation of the electrolyte and the use of additional agents.

A cathode deposit starts as a fine frosting, and with a violent circulation this builds up with perfect smoothness. It is not possible to employ even a rapid circulation, however, on account of the consequent stirring up of anode slimes, and any mechanical scouring effect is therefore lost. On the other hand, the circulation must be maintained at a rate sufficient to supply copper ions at the cathode as fast as demanded by the current density, or other ions will act as carriers of the current and the deposit will become rough and non-adherent. Even under normal conditions fine needles soon spring out in crystal formation. The moment the cathode surface becomes roughened the parts nearest the anode offer the path of least resistance to the current and bad soon becomes worse.

The function of addition agents is first to round off these needles into blunt nodules, and second to change what is called "cocoa matting" structure to a hard compact deposit. Ordinary lubricating oil possesses some property which effects the first and minute quantities of glue the second.

The falling apart of scrap anodes results from incomplete refining of the blister copper in the anode furnace. As the condition causes an abnormal quantity of scrap and leaks from pierced tank linings as well as low-current efficiency the remedy lies in better furnace treatment.

A short circuit between two electrodes is not as serious as at first appears because there is a certain resistance due to conductors and contacts in series with each electrode and a number of parallel circuits. For example, if we have thirty pairs of electrodes and the series resistance amounts to one-quarter of the total across the tank, it is evident that a reduction of 75 per cent of the resistance in one of the thirty parallel circuits will but make it equal to four normal circuits out of the thirty and not draw any great share of the current. Then the increased current flow heats the conductors and contacts affected, and this increases their resistance. Finally, there is a certain rebate on the voltage side due to the lowered resistance of the tank when it comes to pounds of cathode per kilowatt-hour.

In general an economic balance is struck when about 5 per cent of the current is rendered non-effective by local short circuits.

B. Reaction

(*a*) *Deposition of Impurities*.—In the ordinary depositing tank the current consumed in the direct deposition of impurities is obviously negligible, as appears from the great purity of the cathode; in fact, it is an open question whether any of the traces of impurities found in cathode copper are due to electrolytic action. Where insoluble or partly soluble anodes are used and higher voltages obtain, this item becomes measurable. An example of the first case is where arsenic is deposited in a "liberator" tank in copper refining, and of the second where iron is deposited in a copper-nickel refinery.

(*b*) *Gassing*.—A copper cathode rarely shows upon analysis above 99.95 per cent copper. The metallic impurities may total 0.02 per cent, still leaving some unaccounted for difference. Part of this is included electrolyte, but after all allowances are made it seems probable that hydrogen is present either as hydride or by occlusion. We know that some addition agents harden the cathode, and that this hardness may be removed by annealing. When all the copper in a liquor is plated out, as in the case of an electrolytic assay, the gassing does not begin and the voltage rise suddenly upon the exhaustion of the copper, but some gassing starts early and the voltage gradually rises. In the same way local conditions at the cathode due to the moderate circulation employed may cause the separation of a certain amount of hydrogen at the cathode in a normally operating cell. It seems probable, therefore, that a small proportion of the current may be diverted into depositing hydrogen instead of copper, and even a minute quantity of hydrogen will account for a measurable current on account of its very low electrochemical equivalent. For example, 0.03 per cent of hydrogen would take 0.9 per cent of the current. We do not know how much of a source of loss this condition is in straight copper work, but in nickel deposition it may be enormous, free hydrogen appearing in quantity at the cathode.

(*c*) *Valence*.—The efficiency is based upon the reaction

$$CuSO_4 + H_2O + \text{current} = Cu + H_2SO_4 + O$$

where copper acts as a divalent metal. It is evident that should the copper in the electrolyte be present in a cuprous salt, copper might be precipitated at an apparent efficiency of 200 per cent. Cuprous salts are undoubtedly formed to a certain extent at the anode, as shown by the cuprous chloride and metallic dust found in the slimes resulting from such a reaction as $Cu_2SO_4 = CuSO_4 + Cu$, althought the latter is partly due to $Cu_2O + H_2SO_4 = CuSO_4 + H_2O + Cu$.

Cuprous sulphate is very unstable or we should gladly use it as the basis of an electrolyte, and it seems very unlikely that an appreciable amount exists at the cathode. The cuprous chloride found in the cathode when excess chlorides are allowed to accumulate in the electrolyte is doubtless due to direct reduction by the cathode as $CuCl_2 + Cu = 2CuCl$.

C. Cathode Shrinkage

(*a*) *Sulphatizing*.—A certain amount of the deposited copper is redissolved by the electrolyte. While copper is not normally soluble in dilute sulphuric acid, the oxygen dissolved in the electrolyte aids in a slow attack—$Cu + H_2SO_4 + O = CuSO_4 + H_2O$ probably expresses the complete reaction. As would be expected the action is particularly marked at the solution line and various expedients, such as painting or changing the solution level, have to be employed in order to prevent the cathode loops cutting through at the solution line.

The amount of this chemical action is indicated by the growth in the copper content of the electrolyte after correcting for anode impurities dissolving electrolytically and cuprous oxide in the anode dissolving chemically, and it is found to increase rapidly with increase of temperature of the electrolyte.

A fair figure is about 2 per cent of the deposited copper, and if we assume that half of this came from the anodes we have an apparent loss in current efficiency of 1 per cent.

(*b*) *Ferric Salts.*—If the anodes are not free from iron, converter anodes, for instance, and the resulting ferrous sulphate is allowed to accumulate in the electrolyte, there is a tendency, increasing with concentration, for this salt to be oxidized at the anode—$2FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O$. This is particularly the case in insoluble anode tanks where the ferrous sulphate acts as a true depolarizer. This ferric salt is again reduced, either electrically at the cathode—$Fe_2(SO_4)_3 + 2H = 2FeSO_4 + H_2SO_4$—or by the anodes and cathodes chemically—$Fe_2(SO_4)_3 + Cu = 2FeSO_4 + CuSO_4$. In either case there is a diversion of the current from its normal work and a corresponding loss in current efficiency. Under bad conditions, such as obtain in leaching copper ores, this loss may become very serious, but in straight refining work it should be entirely negligible.

(*c*) *Nodules, Etc.*—There is a certain apparent loss in efficiency due to mechanical shrinkage of the cathode from nodules falling into the slimes, chiefly due to inspection work on the tanks. This material is screened out of the slimes later, but is too contaminated to be considered legitimate production. Unless the deposit is rough the amount of this shrinkage will be but a small fraction of 1 per cent.

Summary

The nine sources of efficiency loss are always present, but any or all of them can be kept down to a very small quantity. On the other hand, most of them may become very serious under undesirable conditions. In general we can say that entire disregard of conditions may result in an efficiency as low as 60 per cent, poor work 85 per cent, good balanced operating 92 per cent, and efficiency regardless of expense 99 per cent.

Big Development Expected in Canadian Pulp and Paper Industry.—The large and increasing export of pulp to the American market is expected to cause great expansion of the Canadian pulp and paper industry. Several new plants are being erected and others are under consideration. Canada has the timber and waterpower and comparatively cheap labor to manufacture successfully. Canada will also have a large British market, including Australia and Africa.

Trade Agreements.—The Chamber of Commerce of the United States has received the report of the special committee, recommending that co-operative agreements be permitted under Federal supervision, where natural resources are involved. A condition is imposed, viz., that the agreements tend to conserve the resources and promote safety work. The report has been submitted to several commercial organizations for approval. The plan would empower the Federal Trade Commission to provide a method under which an industry may operate to the common benefit of producers, consumers and workmen. W. L. Saunders, chairman of the board of the Ingersoll-Rand Co., is chairman of the committee.

Manufacturers of Oxygen and Hydrogen in Germany Combine.—The leading oxygen and hydrogen producers in Germany, viz.: The Griesheim-Elektron Co., the Linde Refrigerating Machinery Co. and the German Oxyhydric Co., which between them control about 30 factories have formed a selling combine. Oxygen is said to be selling for 70 pfennig per cubic meter to private consumers and hydrogen for 40 pfennig.

The Nature and Origin of Petroleum and Asphalt

By Clifford Richardson

The writer has advanced the theory* that the origin of petroleum is to be attributed to relations of surfaces and films; that is to say, of films of certain types of natural gas, either as gas or, under pressure at the levels where it exists, in a liquid state, to surfaces of solids, the oil "sands" with which the former comes in contact at considerable depth below the earth's surface. The correctness of this theory seems to be emphasized by the fact that petroleum, wherever it occurs, is accompanied in the "sands" by gas in greater or less amounts, in many cases, in considerable excess. In regard to the origin of the gas no attempt will be made to draw a definite conclusion, as too little evidence is available to permit doing so.

While the writer's conception in regard to the origin of petroleum is purely theoretical, it is suggested and confirmed by studies of the nature and origin of one of the more solid forms of bitumen, that of the asphalt found in the well-known pitch lake in the Island of Trinidad, British West Indies. It appears that a petroleum, existing at considerable depth at that point, is converted to a more solid form of bitumen, asphalt, by coming in contact and being thoroughly emulsified with an aqueous paste consisting of clay, in a colloidal state as regards water, and very fine sand, which is in a colloidal state as regards the highly viscous bitumen. The clay and sand occur as a mud in a spring through which the oil breaks out before reaching the surface and with which it becomes intimately associated, owing to the strong evolution of gas which accompanies the oil as the pressure is released.

The deposit lies in a bowl-like depression, evidently the crater of an old mud spring or volcano, covering a superficial area of about 114 acres and having a depth of more than 135 ft., as shown by a boring made with a wash drill. The boring was necessarily discontinued at this depth, as, owing to the movement of the pitch, the pipe so far departed from the perpendicular as to prevent further work. This movement is due to the evolution of gas on the release of the pressure, to which it has been subjected, on reaching the surface, which is an original component of the petroleum as it is found in the oil "sand." The entire surface of the deposit is in constant motion. It is sufficiently solid to permit of driving a horse and cart over it, and to support, with constant attention, a railroad track for gathering and shipping the asphalt. From its form and environment it is known as a lake. It lies about half a mile from the sea at an elevation of 138 ft. above it.

The material of the deposit is a most unique geophysical phenomenon. At whatever point on the surface or whatever depth it is collected it is found to be of extremely uniform character, as appears from the following data:

AVERAGE COMPOSITION OF TRINIDAD LAKE PITCH IN CIRCLES

	Bitumen by CS_2, per Cent	Mineral Matter, per Cent	Undetermined per Cent
Circle 2, 200 ft. from center	55.02	35.41	9.57
Circle 4, 400 ft. from center	54.99	35.40	9.61
Circle 6, 500 ft. from center	54.84	35.49	9.67
Circle 8, 800 ft. from center	54.66	35.56	9.78
Circle 10, 1000 ft. from center	54.78	35.44	9.78
Circle 12, 1100 ft. from center	54.62	35.45	9.93
General average	54.92	35.46	9.72
Circle 14, 1400 ft. from center	53.86	36.38	9.76
At a depth of 135 feet	54.66	35.90	9.44

*Jour. Ind. & Eng. Chem., Vol. 8, No. 1, page 4, 1916.

In the preceding figures data are given in regard to material, one component of which, water, has been removed by pulverizing and exposure to the air. As a matter of fact, the water present is as constant in amount, 29 per cent, as that of the other components. It is evident that the conditions under which the asphalt is formed involve a state of equilibrium between the components.

Including the water, the composition of the asphalt is as follows:

	Crude Trindad Asphalt, per Cent
Water and gas	29.0
Bitumen soluble in cold carbon disulphide	39.0
Bitumen adsorbed and retained by the disperse mineral matter	0.3
Mineral matter on ignition with tricalcium phosphate	27.2
Water of hydration of clay	4.2

There is a constant influx of new material into the deposit near its center. This is, however, of different character from the main mass. It is, evidently, a freshly formed emulsion of the petroleum and the mud of the spring through which the oil rises to the surface. As a result it is of a very soft character, and can be readily molded in the hands, containing an excess of water not a part of the emulsion. In the course of years this soft material hardens and becomes of the consistency of the main mass of the deposit. This is, no doubt, to be attributed to the surface action which goes on between the colloidal mineral matter and the oil with which it is associated, and it has been observed that where the asphalt has overflowed the rim of the deposit and been exposed, probably for centuries, the surface action has gone further and the bitumen has been converted to a harder form than that found in the main deposit; in fact, differences in this respect can be found between the material near the center of the main deposit and that near its edge.

The origin of this asphalt having been demonstrated to depend upon the relations between heavy petroleum and mineral matter in a colloidal state, the origin of the petroleum itself, it seems reasonable to infer, is to be attributed to a similar condition of affairs in which the natural gas, from its relation to the surfaces of the oil "sand," is converted into petroleum.

It must, of course, be recognized that the surface action going on between a dense petroleum and mineral matter, much of it in a colloidal state as regards water, must be a much more rapid one than between a natural gas and a coarser oil "sand" with which it is brought in contact. But within long periods of time the latter must be quite similar to the former and should account for the origin of petroleum, especially in view of the fact that natural gas consists principally of methane and ethane.

Some natural gases contain hydrogen-sulphide and carbon-dioxide. From the first the petroleums containing sulphur should be derived, although they can also originate in the contact of the oils with sulphur and its compounds existing in the oil "sands"; in fact, free sulphur has been isolated from a Texas petroleum. Carbon-dioxide is an unusual constituent of natural gas, although it occurs in California in a McKittrick well to the extent of 30 per cent. In some of the gases in Trinidad, however, it exists in considerable amount, reaching 33 per cent in a gas which occurs in wells near the asphalt deposit. It is worthy of note also, that in the limited area in which oil wells have been sunk the gas encountered is of very variable composition. Analyses of a number of them, furnished by the writer, have been made by the U. S. Bureau of Mines, which afford the following data:

Composition of Gas from Trinidad, B. W. I.

Identification No.	CH_4	C_2H_6	CO_2	O_2	N_2	H_2S
1	85.1	4.1	9.8	.0	1.0	.0
2	74.2	4.0	20.0	.0	1.0	.8
3	64.7	4.7	26.3	.0	2.7	1.6
4	34.8	27.8	33.5	.0	.4	3.5
5	51.2	15.8	32.0	.0	1.0	.0
6	88.0	10.1	1.7	.0	.2	.0
7	32.4	32.6	25.1	.0	.4	8.7

IDENTIFICATION OF SAMPLES

From Surface of Asphalt Deposit:

1. At center of lake.
2. Where gas bubbles issue violently from surface water at center of lake.
3. Where small bubbles issue gently from surface water at center of lake.

From Oil Wells:

4. Near lake.
5. From well No. 3, 1¼ miles southeast of lake.
6. From well No. 37, 3¾ miles south of lake.
7. From well No. 48, near lake.

In connection with the preceding figures showing the composition of the gases of Trinidad which are closely associated with the formation of asphalt, an examination of that of others from various fields is of interest.

Composition of Natural Gas*

State	Location	CH_4	C_2H_6	CO_2	O_2	N_2	B.t.u.
Cal	Santa Maria	62.7	20.2	15.5	.2	1.4	1,044
Cal	Torrey	54.2	35.6	6.8	.0	3.4	1,240
Cal	Coalinga	88.0	.0	11.1	.0	.9	937
Cal	McKittrick	66.2	1.0	30.4	.0	2.4	724
Cal	W. Los Angeles	91.0	2.7	1.0	.1	5.2	1,019
Cal	Sunset	87.7	.0	10.5	.0	1.8	934
Cal	Fullerton	86.7	9.5	1.7	.0	2.1	1,100
Cal	Kern River	84.3	8.0	6.5	.0	1.2	1,047
Pa	Clarion Co	96.4	2.5	.0	.0	1.1	1,073
Pa	Forest Co	70.8	28.2	.0	.0	1.0	1,279
Pa	Clarion Co	80.5	17.8	.0	.0	1.7	1,189
Pa	Butler Co	53.3	45.8	.0	.0	.9	1,420
Pa	Armstrong Co	81.6	16.9	.1	.0	1.5	1,184
Okla	Osage Co	94.3	.0	1.1	.0	4.6	1,004
Okla	Creek Co	64.1	31.7	2.4	.0	1.8	1,273
Ky	Barren Co	23.6	69.7	2.5	.0	1.3a	1,548
Ky	Barren Co	44.1	48.2	2.6	.0	5.1b	1,367
Utah	Grand Co	90.8	.0	3.6	.0	5.6	967
Utah	Grand Co	90.0	.0	3.5	.0	6.5	959
Ore		96.1	.0	3.0	.0	0.9	1,023
Pa	Crawford Co	6.6	91.1	.0	.0	2.3	1,765
Ore	Tallamock Co	2.0	.0	.1	.0	97.9	21
Nev	Churchill Co	95.6	.0	1.3	.0	3.1	1,018
Ohio	Cuyahoga	80.5	18.2	.0	.0	1.3	1,196
Ohio	Franklin	80.4	18.1	.0	.0	1.5	1,193
Ohio	Hamilton	79.8	19.5	.0	.0	.7	1,213
N. Y.	Erie Co	79.9	15.2	.0	.0	4.9	1,134
Mo	Jasper Co	92.6	4.3	.6	.0	2.5	1,066
Ky	Jefferson	77.8	20.4	.0	.0	1.8	1,205
Texas	Dallas	50.6	10.9	.1	.0	38.4	742
Okla	Nowata Co	96.5	.0	1.3	.0	2.2	1,038

*Bulletin 88, U. S. Bureau of Mines, page 21.
a—H_2S, 2.9 per cent. b—H_2S, 0.1 per cent.

The California gases which are associated with highly asphaltic oils are nearly as variable as those of Trinidad in the percentages of methane and ethane present. They are also characterized by the fact that they carry considerable percentage of carbon-dioxide, in one case as high as 30.4 per cent. One contains a considerable percentage of hydrogen sulphide and the other carries none. In the Oklahoma and Kentucky gases, from which originate petroleums of a semi-asphaltic nature, carbon-dioxide is present to a notable extent. In the gas associated with the purely paraffine oils of Pennsylvania this gas is not found. The question arises whether its presence bears any relation to the formation of asphaltic petroleum. That of hydrogen sulphide might be regarded as having something to do with such a form were it not for the fact that it is absent from the Cali-

fornia gases. The main mass of the gases from the various fields consists of methane and ethane, notwithstanding which fact the petroleums derived from them are markedly different in their characteristics. In the writer's opinion, this leads to the conclusion that the character of the petroleum derived from natural gas is to an important degree dependent upon that of the surface of the oil "sands" with which the gas contacts.

This is the thesis upon which the writer's theory of the origin of petroleum is founded; that is to say, while the gas from which petroleum originates is largely a mixture of methane and ethane, the petroleum originating from these gases varies in character, depending upon the state of subdivision and character of the surface presented to the gases by the "sands" and with which they come in contact. The result is, of course, influenced to a certain degree if the natural gas contains hydrogen sulphide, and apparently, also, to a considerable extent if there is a larger percentage of carbon-dioxide present, in this case asphaltic oils being formed.

In certain fields natural gas occurs which is not associated with petroleum. In this case it must be assumed that the gas does not remain in contact with the "sands" for a sufficient length of time to accomplish this, or the surfaces are not such in area or in character as will bring about its condensation to petroleum, the time factor being an important one.

New York City

New Developments in Nickel Industry.—The new refinery of the International Nickel Company in Welland, Ontario, will be completed in about twelve months. Actual operations on the building of another refinery for the British-American Company will soon be commenced. These developments will make greater demands on Ontario for nickel ore. The value of the nickel output of Canada for 1916 is estimated to be $23,000,000. The first and largest producer is the International Nickel Co. (Ambrose Monell, President), which does its refining in New Jersey, but smelts the matte in Sudbury, through the Canadian Copper Co., which it controls. The other corporation is the Mond Nickel Co. of Great Britain, whose head is Sir Alfred Mond, the prominent Liberal member of the British House of Commons. The Mond Nickel Co. also smelts its ore into matte at Coniston, Ont., and the matte is refined at Clydach, Wales, those works being greatly enlarged in 1914. The International Nickel Co. takes practically all of the 59,000,000 pounds which is shipped to the United States, and the Mond Co. all of the 12,000,000 pounds, which goes to Great Britain.

A third corporation was organized in July, 1913, under the name of the Canadian Nickel Corporation, but in the following month the name was changed to the British-American Nickel Corporation, and its plans are now taking more definite shape. The company bought up the nickel interests of the late John R. Booth and others, and now controls 17,000 acres of Sudbury lands, and has obtained the Canadian rights to a Norwegian process known as the Hybinette (after the name of one of the members of Hybinette, Borthen & Henricksen, who operate the only large successful mine of Norway at Evje, refining at Christiansand). It is claimed that with this process nickel can be produced 99 per cent pure. The nominal capital of all the Canadian nickel companies is about $100,000,000. The capital of the International Nickel Co. is $62,000,000, but of this only $2,500,000 is in the Canadian Copper Co. The capital of the British-American Nickel Corporation is $30,000,000. Mr. E. P. Mathewson, the well known Anaconda metallurgist and manager of the Washoe Reduction Works, has gone to Canada to assume the management of the British-American Company.

The Utilization of Waste Heat for Steam-Generating Purposes*

(Concluded from Vol. XV, page 708)

Beehive Coke Ovens

While it is true that beehive coke ovens are gradually being replaced with by-product ovens, there are still a very large number of the former in operation. Since there are few, if any, coals from which good coke can be made in beehive ovens that cannot be satisfactorily coked in by-product ovens if properly handled, it is questionable whether more beehive ovens will ever be built. On the other hand, it will be a number of years before all of the existing beehive ovens can be replaced by the more modern type.

The total coke production of the country in 1913 was 46,300,000 net tons, and of this quantity the production of by-product ovens was 12,715,000 tons, or 27.5 per cent of the total. The total estimated production in 1916 is 55,000,000 net tons, of which approximately 19,000,000 tons, or 34.4 per cent, will be produced in by-product ovens. By 1918 it is estimated that the production from by-product ovens will be somewhat over 50 per cent of the total production of the country.

It is not in the province of the present paper to discuss the merits of the two systems. This class of waste heat is dealt with here because of the very remarkable results that are being secured from modern waste-heat boilers utilizing gases from beehive ovens, and because of the possibilities of saving, due to this utilization, until such time as beehive ovens are replaced. Furthermore, there are available figures from boiler installations made a number of years ago for this class of work, and from a comparison with the results secured to-day the great advance in the design of waste-heat boilers may be readily seen.

From the nature of the beehive oven coking process, the quantity of gas available from each oven is large. These weights will vary with the analysis of the coal coked and the class of coke being made. The analysis of the gases escaping from the individual ovens will vary widely during different periods of the coking operation. Where a large number of ovens, however, are connected by a single flue to a boiler, or boilers, the average analysis at the boiler entrance will not show a particularly wide variation due to the fact that different ovens in the range or block are at different stages of coke making. At certain periods during operation large quantities of carbon monoxide pass off from the ovens and burn in the flues; in no plant investigated has there been noticed any secondary combustion within the boiler. For estimating purposes, the gas weight available may be taken as from 6 to 7 lb. per pound of coal coked per hour.

The temperature of the gases leaving the individual ovens is high, probably averaging between 2000 and 2200 deg. The temperature of these gases as they enter any boiler that is installed will depend upon the length, design and location of the connecting flues. Some typical entering temperatures are given in Table 5.

As far as is known, the first water-tube boilers installed in this country for this class of waste-heat work were placed in operation in 1900 at Greensburg, Pa. Due to improper design of connecting flues, these boilers were not successful in the utilization of the waste gases, and shortly after their installation were changed to coal-fired boilers.

*A paper read before the American Society of Mechanical Engineers on Dec. 16, 1916, in New York. All temperatures in this paper are given in degrees Fahrenheit.

Rather complete figures are available from three different plants in which boilers are installed for this class of work, the first two representing early waste-heat practice and the third representing the modern waste-heat boiler.

TABLE V—RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR BEEHIVE COKE OVENS

Test Number	1	2	3	4
Plant	Priestman Col. Ltd.	Frick Coal & Coke Co.	....	....
Location	Newcastle-on-Tyne	York Run, Pa.	....	....
Boiler	Stirling	Stirling[1]	B. & W.	B. & W.
Heating surface, sq. ft	1,610	10,800	10,200	10,200
Gas weight, lb. per hr	23,200	83,650	125,500	155,100
Gas per hr. per sq. ft. of h.s., lb	14.4	7.7	12.2	15.2
Temperatures:				
Gas entering boiler, deg. Fahr	1,720[2]	1,804	2,329	2,158
Gas leaving boiler, deg. Fahr	650	490	463	477
Drop in temp., deg. fahr	1,070	1,314	1,866	1,681
Draft at boiler damper, in	0.56	0.56	4.0	4.4
Draft at boiler inlet, in	0.24	0.30	1.9	2.0
Draft loss, in	0.32	0.26	2.1	2.4
Horsepower developed	187	824	1,756	1,956
Per cent of rated capacity	116	76	172	192
Approximate transfer rate (R)	4.7	3.2	5.6	6.8

[1]Three boilers, each of 3600 sq. ft. heating surface.
[2]Temperature leaving ovens 1970 deg. Fahr.

The first plant is that of the Priestman Collieries, Ltd., near Newcastle-on-Tyne, England. Here a Stirling boiler, rated at 161 hp., was connected to 22 beehive ovens producing coke from an average of 3800 lb. of coal per hour for the 22 ovens, or 173 lb. per hour per oven.

The second is at the York Run, Pa., plant of the H. C. Frick Coke Company. In this installation there are three Stirling boilers having approximately 3600 sq. ft. of heating surface each, though the boilers were rated at the time of purchase as 300 hp. each. These three boilers were connected to a range of 50 ovens, and during the week devoted to boiler testing, there were on an average 44 ovens in service which were coking coal at the rate of 13800 lb. per hour, or 314 lb. per oven per hour.

It has not been possible to secure permission to name the owners of the third and distinctly modern installation, although they have kindly consented to the publishing of some of the results secured from the first unit put into service. This installation consisted of a Babcock and Wilcox boiler 18 sections wide, each section being made up of twenty-six 20-ft. tubes and containing 10,200 sq. ft. of heating surface. The boiler is equipped with a superheater and furnished with a turbine-driven induced-draft fan.

During the time the tests were run on the Babcock and Wilcox boiler the ovens were being operated to meet plant demands for coke, some ovens making 24-hour, some 36-hour and others 48-hour coke. The speed of the fan connected to the Babcock and Wilcox boiler was regulated to handle an approximately constant weight of gas, and as ovens were cut in or cut out, other boilers would be put into service and taken off again when the gas weights were reduced. Because of this fact it was practically impossible to determine the actual amount of coal coked corresponding to the capacity developed by the Babcock and Wilcox boiler. It is possible, however, to check pretty definitely the gas weight passing through the boiler, and from this weight approximate the coking rate corresponding to the horsepower developed.

The performance of the first boiler unit has been so satisfactory that the owners have purchased, since its installation, six additional units for use with their ovens. These are similar to the one described, except that they are 27 sections wide instead of 18, each unit containing 15,300 sq. ft. of heating surface, or a total of 9180 hp. for the six units.

The results of two of a series of tests on this Babcock and Wilcox boiler, together with the results secured at the other two plants described, are given in Table 5. In this table the gas weights, while approximate, are certainly within 10 per cent of the actual weights.

The baffle arrangement in the boiler at the Priestman Collieries is not known. It is probable, however, that the gas-passage areas were somewhat larger than standard, as the draft loss through the boiler is considerably less than would be expected for an equal weight of gas in coal-fired practice. The exit temperature is high but, considering the design of boiler and the weight of gas, cannot be considered excessive. In the report covering the series of tests from which this was taken, a statement is made to the effect that the capacity obtained did not represent the maximum, as, due to a

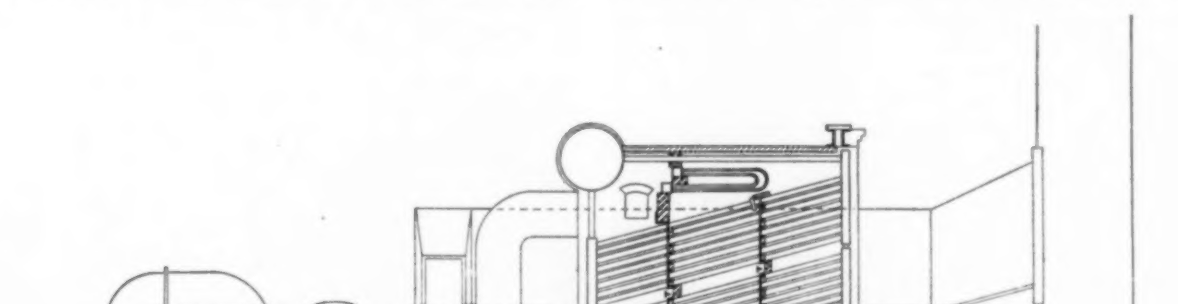


FIG. 7—REHEATING FURNACE AND WASTE-HEAT BOILER ARRANGEMENT

leaky damper, all of the gases from the ovens were not passed through the boiler.

In this plant the boiler was at the end of a range of 22 ovens. The flue was thus rather short, and because of the very low draft requirements of the ovens and natural-draft stack, provided sufficient draft for proper oven operation.

The test at the Frick plant extended over a full week's run of 168 hours. As stated, 44 of the ovens were in operation during the test, the ovens making 48-hour coke and half the number being charged each day with the object of maintaining even gas conditions. Gas weights and temperatures did vary considerably throughout the week. The lowest temperature noted was approximately 1500 deg., while the highest was 2075. The gas weight here corresponds to about the weight that would be passed through the boilers if they were being operated at about rating, coal-fired. The baffles in these boilers were standard, and the draft loss checks the statement made as to rating.

Under such conditions the exit temperatures, which varied during the test from approximately 475 to 550 deg., and averaged, as given, 490 deg., are no lower than might be expected.

The boilers at the Frick plant were located at the middle of a range of 50 ovens, so that the length of flue on either side was not excessive, and the draft requirements could be readily met by a stack 150 ft. high.

In Tests 3 and 4 the interesting features are the low exit-gas temperatures and the high capacities. The exit temperatures of 463 and 477 deg., for ratings of 172 and 192 per cent respectively, are lower by a considerable amount than would be obtained with coal-fired boilers at equal ratings. The design of the boiler to give the high heat-transfer rates noted offers sufficient explanation for these temperatures. In other tests of the Babcock and Wilcox boiler in this series, where the gas weights were such as to give approximately 96 and 128 per cent of rating with entering-gas temperatures of 2013 and 1811 deg., the exit temperatures were 437 and 428 deg., respectively.

At this plant the boilers were at the end of the blocks of 100 ovens and the connecting flues were of considerable length. This explains the necessity for the greater draft suction found at the boiler inlet in this boiler as compared with that in the plants previously described. The draft loss through the boilers is high, but is no more than would be expected when the weight of gas and the area of gas passage are considered. The fan, as stated, was turbine-driven, and a large proportion of the power required for this drive was returned through the exhaust to the feed water.

In this class of work the saving due to the utilization of waste heat is solely in the value of the steam generated. The amount of such saving may be approximated from the boiler capacities given in Table 5. As stated, the gas weight available will be approximately 6.5 lb. per pound of coal coked per hour. On this basis it will be noted from Tests 3 and 4 that 1 hp. was developed for 11.0 and 12.2 lb. of coal coked per hour, respectively, and it would seem conservative to state that with the modern design of waste-heat boiler a horsepower may be devloped on the waste gases from 15 lb. of coal coked per hour. At such a return, even granting that beehive ovens will ultimately be replaced with by-product ovens, it would seem that, in numerous plants, an installation of waste-heat boilers would pay for itself many times before such a change could be made. It would be entirely possible, too, in these installations, to design the boilers in such a manner that at the time of replacing the beehive ovens the boilers could be dismantled and reset either for burning coal or coke breeze, or to be fired with by-product coke-oven gas.

Heating Furnaces

The first boilers for any class of waste-heat work were unquestionably installed with heating furnaces of different descriptions, and the early history of boilers with heating furnaces is in reality the early history of the utilization of waste heat in general. While the writer does not know the actual date of the first installation, it is certain that it was previous to 1872. Before that date such boilers as were used in connection with heating or puddling furnaces were of the cylinder or two-flue design.

An article in the *Iron Age* of April 6, 1893, describes the early installations of water-tube boilers for this class of work and gives some more or less complete results of the performance of a number of these boilers. The first of these installations was made at the plant of the McCullough Iron Works, Wilmington, Del., in 1874, and consisted of two boilers of the Babcock and Wilcox design made up of seven sections of six 16-ft. tubes. Each boiler contained 860 sq. ft. of heating surface and in accordance with the practice of the day were rated on the basis of 11½ sq. ft. per horsepower, or 75 horsepower. To quote the journal mentioned: "These boilers, erected seventeen years ago, have been in constant use ever since and have given entire satisfaction."

TABLE VI—RESULTS OF TESTS OF WASTE-HEAT BOILERS WITH STEEL FURNACES

Test Number	1	2	3[3]	4[3]	5[3]
Plant	Penn. Bolt & Nut Co.	Cambria Steel Co.	Bethlehem Steel Co.		
Location	Lebanon, Pa.	Johnstown, Pa.	So. Bethlehem, Pa.		
Furnace	Puddling	Heating	Structural Mill Reheating Furnace		
Boiler	3 Pass. B. & W.	Single Pass B & W.	B. & W.	B. & W.	B. & W.
Heating surface, sq. ft.	1196	2,998	5,840	5,840	5,840
Gas weight, lb. per hr.	......	16,150	87,571	63,932	80,757
Gas per hour per sq. ft. of h.s., lb	......	5.4	15	11	13.8
Temperatures:					
Gas entering boiler, deg. Fahr.	......	1,990[1]	1,745	1,071	1,445
Gas leaving boiler, deg. Fahr.	542	729[2]	436	401	418
Drop in temp., deg. Fahr.	......	1,261	1,309	670	1,027
Draft at boiler damper, in.	0.32	0.23	1.87	1.15	1.50
Draft at boiler inlet, in.	......	0.19	0.68	0.39	0.54
Draft loss, in.	......	0.04	1.19	0.76	0.96
Horsepower developed	73.2	152.8	784.1	326	542
Per cent rated capacity	61	50.9	134	56	93
Approximate transfer rate (R)	......	1.7	6.1	5.0	5.4

[1]Optical pyrometer.
[2]Varied at different periods of furnace operation from 604 deg. to 920 deg.
[3]Tests 3, 4 and 5 on same boiler. No. 3 represents 12-hr. period during which the structural mill was in operation, No. 4 a 12-hr. period with the mill not operating, and No. 5 a continuous run of 104 hr. during which the mill operated 56 hr. and was not in service 48 hr.

A number of boilers similar to these were installed after 1874 in the different iron and steel plants throughout the country. Test 1, Table 6, is representative of the performance of this design of boiler. This test was conducted by J. de Kinder at the plant of the Pennsylvania Bolt and Nut Company, Lebanon, Pa. At this same plant a test on a cylinder boiler in the same service showed exit temperatures considerably in excess of 1000 deg. as compared with 542 deg. for the water-tube boiler, and this temperature difference probably represents the difference in efficiency of the two types of boiler in this class of work.

It is of interest to note that the early waste-heat water-tube boilers with heating furnaces were of the three-pass design. There were, however, a number of factors in heating-furnace work which enabled satisfactory results to be obtained from a design that later was considered more or less impracticable for other classes of waste-heat work. The chief of these was the fact that the draft required at the outlet of the ordinary heating furnace was very low. The boilers were ordinarily set directly over the furnace, and the draft loss between the furnace and boiler was negligible. Furnaces were not driven at the time of the early in-

stallations at a rate that is at all comparable with present-day capacity, and the gas weights to be handled were very low. Further, the boilers were wide and long compared to the height, so that the gas-passage areas were large in comparison to the heating surface. The high exit temperatures ordinarily found enabled a given height of stack to give a greater draft than would the same height under coal-fired conditions.

In 1892 a type of single-pass waste-heat boiler was introduced by The Babcock and Wilcox Company. It is not quite clear why such a design was developed, but the presumption is that with increased furnace capacities the draft loss through a sufficient amount of heating surface in a three-pass design was great enough to interfere with the operation of the furnace. These boilers were of standard sectional Babcock and Wilcox design, but with tubes of 8, 9 and 10 ft. in length. The heating surface required to cool the gases sufficiently was obtained in the height of the boilers, and these were made from 18 to 27 tubes high.

The first boilers of this description were installed in the rolling mill of N. E. Ayre and Company, Portland, Ore., in 1892; one boiler being set over a box-scrap-heating furnace and the second in connection with a small billet-heating furnace. The *Iron Age* article, to which reference has been made, gives some figures on the performance of these boilers, but inasmuch as no temperature or draft measurements are reported, the figures are not included in Table 6. There are included in this table, however, results secured from a boiler of similar design installed in 1901 at the plant of the Cambria Steel Company, Johnstown, Pa. This boiler was of the single-pass type, made up of 10 sections of 27 tubes 10 ft. long and rated at 300 hp.

The results as compared with the earlier three-pass boilers are considerably in favor of that type. Some 7500 hp. of the single-pass design were installed, and in general the results secured were considered commercially satisfactory. Occasional installations of this design of boiler are still made. Because of the construction the boiler was expensive, and probably for this reason was never as popular as the next design of single-pass waste-heat boiler.

This was the Cahall waste-heat boiler, introduced in 1894 by the Aultman and Taylor Machinery Company. This was a single-pass vertical boiler in which the gases were introduced through an annular ring in the mud drum. Baffles were placed in the cone between the tubes with the object of throwing the gases into the tubes, but in view of the temperatures frequently encountered, it is questionable how long such baffles remained in place.

The results secured with this type of boiler were about in line with those of the previous single-pass type, though for a given set of conditions the exit temperatures were probably slightly higher. The Cahall boilers were popular, however, in the iron and steel industry, and over 20,000 hp. were installed. A number of these boilers were fired with blast-furnace gas and were not, therefore, waste-heat boilers.

Other types of boilers were used in this waste-heat work, but the three designs described were by far in the most general use. All of the boilers used were such as to give a minimum draft loss for the amount of gas to be handled, and in this way interfered in no manner with the operation of the primary furnaces.

In 1914 the first waste-heat boilers of strictly modern design and utilizing the theory of high gas velocity were installed for this class of work by the Bethlehem Steel Company. These boilers were of the general design described in connection with open-hearth steel practice, and were made up of 19 sections of 17 tubes 16 ft. long. They were rated at 584 hp. each, were equipped with superheaters designed to give approximately 75 deg. of superheat, and furnished with motor-driven induced-draft fans. They were set in connection with two 28-in. structural-mill reheating furnaces, the approximate arrangement of furnace, boiler and fan being shown in Fig. 7. An extensive series of tests was run on one of these boilers in the early part of 1915. During these tests the structural mill was operated during certain shifts of 12 hr., while during other shifts the mill was not in service, though the furnace was kept hot. Under these conditions, since the temperatures were considerably lower while the mill was in operation, tests covering a wide range of gas temperatures are available, and the boiler performance under such conditions may be noted. Table 6 gives three of the tests on this boiler. Test 3 of this table represents a 12-hr. period during which the mill was in operation, Test 4 a 12-hr. period during which the mill was out of service, and Test 5 a continuous run of 104 hr., during which the mill was being operated for 56 hr. and was out of service 48 hr.

As in all previous tests, the interesting feature brought out by a comparison of early and modern results is the increase in capacity and decrease in exit temperatures in favor of the modern design. These lower exit temperatures further are secured with gas weights per square foot of heating surface greatly in excess of early practice.

The draft loss through the modern boiler, as indicated in the last three tests of Table 6, is reasonably high, though not nearly as great as found in open-hearth and cement plant waste-heat practice. Since the fan on this boiler was motor-driven, none of the power required for such drive could be reclaimed in the boiler feed. The amount of power required however was small, the maximum for the whole series of tests being about 2 per cent, while the average was 1.55 per cent of the total power generated by the boiler.

In this class of work the only saving through the use of waste-heat boilers is the value of the steam generated. This, however, is certainly a considerable item, and it would appear that there are numerous industrial furnaces that are similar to heating and puddling furnaces and where the temperatures are comparable, with which the installation of waste-heat boilers can show a handsome profit on any investment made.

Miscellaneous

While by far the greater number of waste-heat boilers in service are in the industries outlined above, there are numerous installations in plants of different character. In this miscellaneous class the number of installations in any single industry is small, but it appears advisable to make reference to certain of these, if only to give an idea of the wide and varied field for development in the use of waste heat.

Zinc Furnaces.—The writer has knowledge of over 11,000 hp. of waste-heat boilers set in connection with and utilizing waste gases from zinc furnaces. The temperatures in this class of work are high, being ordinarily in excess of 2000 deg. with certain designs of furnaces and probably averaging well over 1700 deg. with all classes. The draft requirements for the zinc furnace itself are low and, in fact, a number of furnaces are operated with a slight pressure at the exit. Because of these facts, the larger part of the installations with such furnaces has consisted of boilers that are practically standard in design. With

furnaces in which the ore treated is in contact with the gases, fears of the building-up on the tubes of an objectionable deposit led to a modification of boiler design to give more than the customary access to the heating surfaces, in order that all possible might be reached and brushed down should occasion demand. In refining furnaces, where the gases do not come in contact with the metal treated, there is, of course, no danger of such deposit, and standard boiler designs work out satisfactorily.

The results secured from these standard boilers have been entirely satisfactory, and from a commercial standpoint the return in all cases has shown that the expense of the installation has been more than warranted.

One of the first concerns using waste-heat boilers in this class of work for years installed units that essentially were of standard design. As the modern waste-heat boiler was developed, however, this company was persuaded to install such a unit, though the gas velocities were not quite as high as could be desired for the best results. No complete figures of the performance of the modern design as compared to the standard design are available, but the exit gas temperatures from the two designs are indicative of the higher efficiency of the former. One large installation of the modern type of waste-heat boiler has been purchased. These units are not as yet in service, however, and no results are available, but from our knowledge of waste-heat boilers in general there appears to be no reason why the performance should not be in line with known performances in other branches of the work.

Nickel-refining Furnaces.—The International Nickel Company (Orford Copper Works) has in service over 3000 hp. of waste-heat boilers set in connection with nickel-refining furnaces. As in the case of zinc furnaces the temperature of the waste gases is high. While it varies during different portions of the operation, the average is probably in the neighborhood of 1700 deg. when leaving the furnace. The boilers at this plant are of practically standard design, such as used for coal fuel, insofar as baffle arrangement is concerned. No complete test figures are available, but from data at hand the boilers are developing over 90 per cent of their rated capacity with exit gas temperatures of approximately 600 deg. With such a temperature leaving the boiler and a draft resistance through the boiler corresponding to about rating in coal-fired practice, the low draft requirement at the furnace exit is readily met by a 100-ft. stack.

These boilers, as stated, are of practically standard design. As compared with the exit temperature of 600 deg. actually being obtained it would be entirely possible, with the modern type of waste-heat boiler, to reduce this to 450 deg., corresponding to an increase of over 13 per cent in capacity. On the other hand, the design of boiler in use is developing approximately its rated capacity with gases that previous to 1911, the date of the first installation, were wasted. The success of the first units installed was such as to cause this company to duplicate them in later installations, and since these waste-heat boilers have made it possible to shut down a large portion of the coal-fired boiler plant, there was no apparent reason for changing the first design.

In this class of work, as with copper-refining furnaces, the saving due to the reclamation of dust within the setting is an item that compares favorably with the saving, due to the steam generated from the waste gases.

Gas Benches. Several installations of the modern type of waste-heat boiler in small units have been made in connection with the illuminating-gas benches. The gas temperatures leaving the benches vary somewhat at different periods of the cycle, but where a number of benches are connected to a single boiler—and this is necessary to get a practicable weight of gas—the temperatures entering the boiler are reasonably constant. Complete figures are available of a test run on a modern design of waste-heat boiler in this class of work. The boiler in question has 1330 sq. ft. of heating surface, is equipped with a superheater, and furnished with an induced-draft fan. The boiler is connected to five gas benches, using an average of 211 lb. of coke per hr. per bench. The average temperature of the gases leaving the benches in the test was 1484 deg., while the average temperature entering the boiler was 1225 deg. The boiler test was run at the time the gas benches were first put in operation, and the temperatures, both leaving the benches and entering the boiler, are in all probability somewhat higher than would be the case after normal operating conditions were established.

Under the above conditions, the boiler cooled the gases to approximately 450 deg. (though this figure was undoubtedly affected somewhat by leakage at the damper) and developed 106 h. p., or 79.3 per cent of its rated capacity. The draft loss through the boiler was slightly less than 1 in. While this is not high as compared with other waste-heat work, when it is remembered that the boiler must be at some distance from the furthest bench and hence the connecting flue be of considerable length, and also that approximately 0.75 in. or 1 in. of draft is necessary at the bench outlets, the impracticability of a natural-draft stack, where a boiler is installed in this class of work, is obvious.

In the plant in question the waste-heat boiler generated not only sufficient steam for the requirements of the coal-gas section of the plant, which are low, but a surplus that was almost sufficient for the operation of the water-gas department of the plant.

Oil Stills. At least two installations of the modern type of waste-heat boilers have been made in connection with oil stills, though, aside from the statement to the effect that these boilers are giving satisfactory service, nothing definite on their performance is available.

In this class of work it would appear that the amount of gas available is dependent, to a certain extent, upon the operation of the still, though from reports at hand it would seem safe to figure on approximately 22 to 24 lb. of gas per lb. of oil burned under the stills. The temperature of such gas at a point corresponding to the boiler inlet is approximtely 1000 deg., and because a number of stills are connected to a single boiler, this temperature is practically constant.

With the modern design of boiler, as in other waste-heat work, the draft loss is high, and as a draft of approximately 1 in. is required at the stills for proper operation, induced-draft fans are necessary in this class of work.

Embargoes.—From France the exportation of the following articles is no longer permitted: Oxalic acid, albumen, chlorine compounds, carbon chloride, iron or ordinary steel cutting tools, tools and detached parts, machine parts and all other articles in special steel except clock-makers' tools. From Norway copper substitutes and all kinds of rolled and drawn iron wire, condensed milk, cement and bamboo cases may no longer be exported.

FIG. 1—A VIEW OF THE SALT DISTRICT—LUMBER RAFTS ON THE RIVER

FIG. 2—TZULIUTSING—A VIEW FROM THE RIVER

The Production of Salt in Szechuen Province, Western China

By H. K. Richardson

Situated at the extreme western border of China is the isolated mountain province of Szechuen, the largest in area, the most populous and wealthiest province of China. Much has been written of the coal, copper, zinc, antimony and other mineral resources of this wonderland of nature, but little has been published regarding the work of the people. The activities of the Szechuenese that have made them famous all over China are: (1) The highly productive salt districts of the province; (2) the production of sugar and sugared fruits; (3) the fine silk, mostly crêpe, sent to all parts of China; (4) the great variety of skins or furs exported, 1,500,000 pieces passing the Chungking custom house per year, and (5) the vast quantity of herbs gathered for medicine, $1,000,000 worth passing the Chungking custom house for export per year.

The most interesting of all these industries to the chemical engineer is the production of salt. The rela-

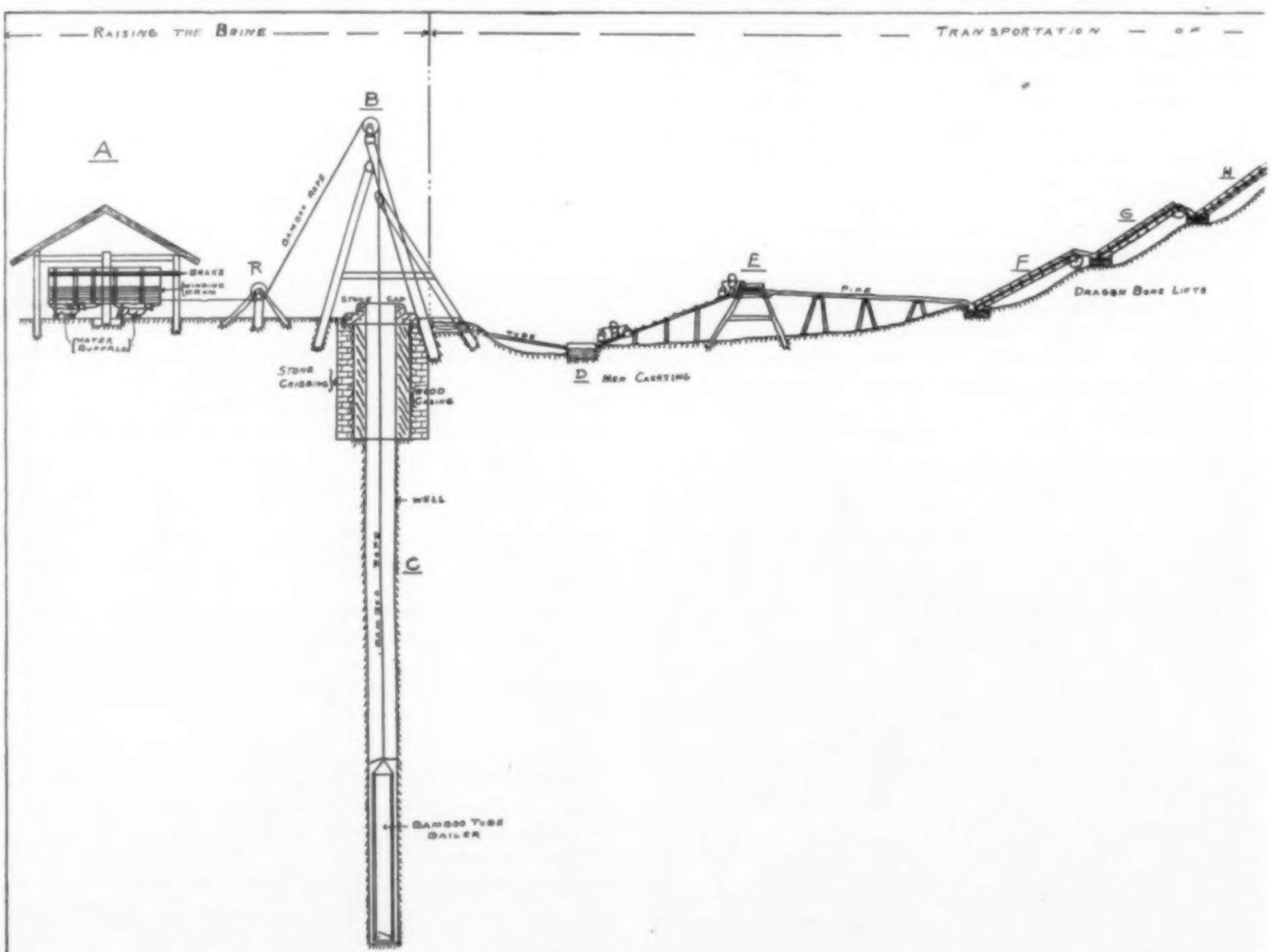


FIG. 4—DIAGRAM SHOWING THE SUCCESSIVE STEPS OF THE CHINESE SALT

tive importance of the salt production of this province to the total production in China is readily seen from the following figures:

1915, total consumption of salt in China ....3,366,000,000 lb.
1915, total salt produced in Szechuen.. 735,000,000 lb.

The Szechuen product is consumed locally and in the provinces of Hupeh, Kueichow, Yunnan, and Kansu, supplying probably 100,000,000, or one-quarter of the population of the republic with this necessity of life.

The salt-producing territory of the province is situated along the river bottoms and hillsides bordering the many streams between longitude 104 deg. and 110 deg. east and latitude 29 deg. and 31.5 deg. north. The whole area covered is about 32,000 square miles.

All of the salt produced is obtained by the evaporation of brine. The brine is obtained from three general types of wells:

1. Salt springs either on the surface or at the bottom of shallow pits. This type is found mostly in the eastern end of the district. The best illustration of this type is the well at Kwei Chow Fu.

2. Wells drilled through clay and soft rock to 1000 ft. This type of well is the most prevalent in the province, and is illustrated by the wells at Tai Ho Chen on the Chengstu-Wanhsien postroad and Chien Wei Hsien on the Min River near Kiating.

3. Deep wells drilled through hard limestone to 3000 to 4000 ft. All wells of this type are found at Tzuliutsing, in the southwestern corner of the salt well district.

In this article the wells at Tzuliutsing, which are the largest and most famous wells for salt production in China, will be described, while a future article will deal with the more numerous, smaller, but none the less interesting wells.

Tzuliutsing is a subdistrict made up of a combination of three market towns of the Fu Shun and Yung

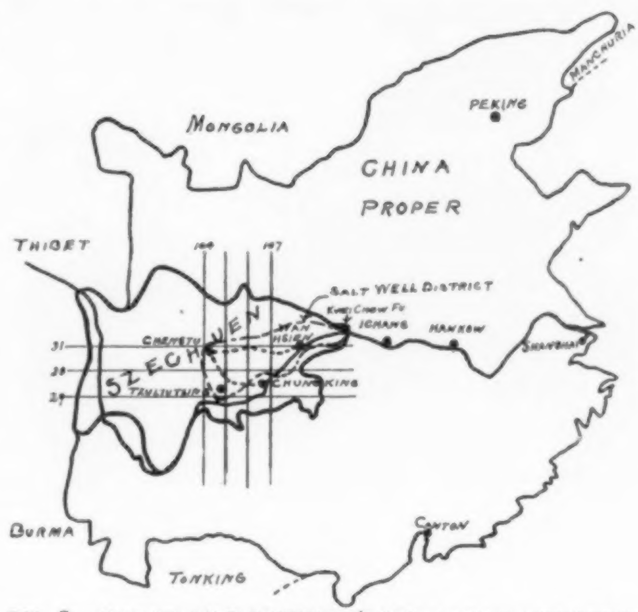
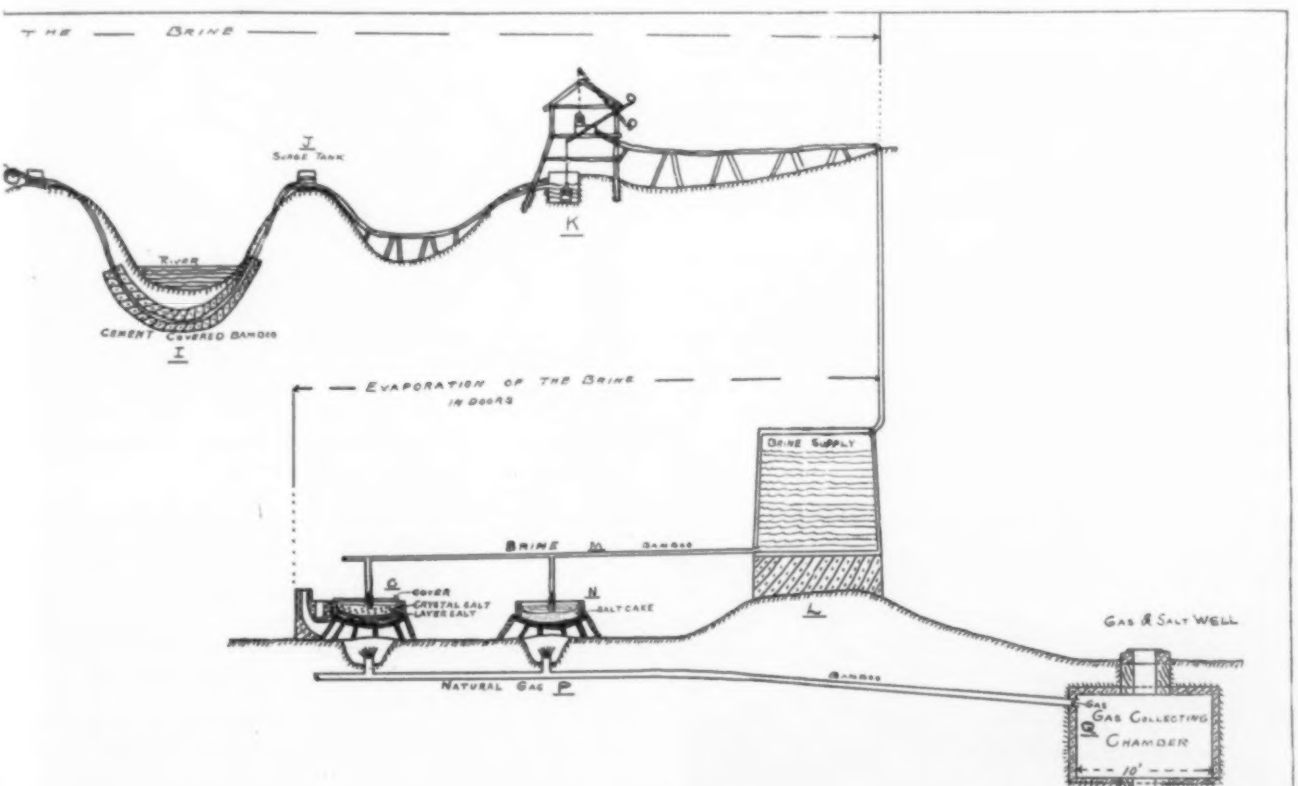


FIG. 3—MAP OF SALT DISTRICT (DOTTED LINES REPRESENT POST ROADS)



INDUSTRY (RAISING THE BRINE, TRANSPORTATION, EVAPORATION)

FIG. 5—EMPTYING THE BAMBOO BAILER

Hsien districts of the province of Szechuen. It is 110 miles west of the treaty port of Chungking and 100 miles southeast of Chengtu, the capital of the province (see map, Fig. 3).

The history of these wells is obscure, but they are mentioned in the provincial histories of a thousand years ago. Inquiry as to how the wells were discovered reveals the fact that at the high stage of the river there is a spring on the hillside that bubbles out brine. The district takes its name from this spring, for Tzu Liu Tsing means "Self-Flowing Well."

There are three distinct sections to the district:

In the Deep Well Section the wells are driven through sandstone and are from 2500 to 4000 ft. deep. Natural gas is obtained from some of the wells in this section and used for evaporating purposes. This is the most important section and produces three-quarters of the salt of the district.

In the Medium Well Section the wells are from 1000 to 2000 ft. deep.

In the Shallow Well Section the wells are from 200 to 1000 ft. deep and coal is used to evaporate the brine.

The technique of the process in the three districts is the same except for the evaporating, since practice during more than a thousand years has made the process uniform at the various wells. There are no secret processes, and anyone is free to look around as he pleases.

The operations used to obtain the salt will be considered under the following heads: Well drilling, process and costs; pumping or drawing the brine, process and costs; transportation of the brine; evaporation of the brine, process and costs; transportation and cost of salt.

FIG. 6—WINDING DRUM AND DERRICK

Well Drilling

After the location of a new well is decided upon, the first thing is to build a house, derrick and winding drum at that place. The derrick (Fig. 4, B) is made of pine trees. To get the necessary length several trees are spliced together; to get the needed cross-section three trees are bound together with a 1-in. bamboo rope, making a triangular log 20 in. on a side (see Fig. 5). To keep the binding bands tight wooden wedges are driven under the rope.

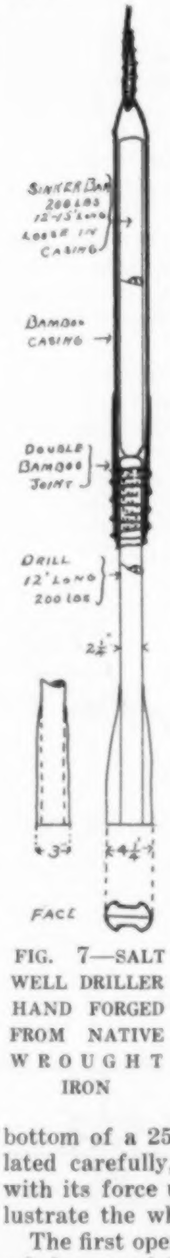


FIG. 7—SALT WELL DRILLER HAND FORGED FROM NATIVE WROUGHT IRON

A pulley $2\frac{1}{2}$ ft. in diameter, made of oak with sides extended to form a groove, is placed on the top cross bar of the derrick; the lifting rope for drills or bailer runs over this pulley, under another larger pulley (5 ft. 6 in. in diameter) held firmly in position by a weighted framework (Fig. 2, R) to the winding drum (Fig. 2, A). The pulley and derrick can well be seen in Fig. 6.

The drum resembles a ferris wheel laid on its side, and is made of wood and bamboo. There are no nails in its construction, all joints are mortise and tenon or tied with bamboo rope. The drum usually has sixteen sides and will wind from 54 to 65 ft. of rope to a turn. It is 7 ft. high and is set 5 ft. up from the ground so as to allow the draught animals to pass under the rope, which winds onto the framework near the bottom.

At the top of the framework is the brake. This is a bamboo tube split on one side and opened out its full width, making a bamboo piece 12 in. wide and the thickness of a bamboo. One end of the brake is firmly secured to one of the shed posts, while the other is tied by a bamboo rope to an adjoining post. To use the brake the brakeman pulls down on the bamboo rope until his whole weight is acting to tighten the band and slow down the drum to the desired speed.

When lowering the bailer the drum gets up quite a speed, for it makes fifty revolutions in eighty seconds, the time necessary for the bailer to reach the bottom of a 2500-ft. well. The brake must be manipulated carefully, for the bailer must not strike bottom with its force unabated. Fig. 2, A. R. B, and Fig. 6 illustrate the whole apparatus.

The first operation in sinking the well is to quarry out a hole several feet in diameter and 200 ft. Chinese deep. (One foot Chinese equals 1.11 ft. English.) Into the center of this excavation a wooden pipe is placed. This pipe is made from "Song Mu," a wood similar to Georgia pine. The tree is cut into 10-ft. lengths, sawed in halves lengthwise and the heart gouged out to make a 6-in. semicircular hole. The two halves are then bound together, making a wooden pipe 6 in. inside diam. with sides 4 in. thick. These pipes placed end to end in the excavation, are accurately centered and made vertical, then secured in place by stone cribbing.

This tube is, in fact, the guide by which the drilling is started, and unless they are carefully placed there will be trouble a-plenty in the future drilling work. More than a thousand years of experience have taught the Chinese that this work must be accurately done to insure a right start, so more care is exercised in this work than is usual in things Chinese. The top of the well is capped with a heavy piece of limestone, cut about 30 in. square and 20 in. thick where the 6-in. hole pierces it. These caps prevent the top of the wooden pipe from being split or abraded by the descending tools.

The drilling is done with a iron spud drill. To make the drill heavier and work better an iron rod is put into the bamboo casing above the drill proper. This serves to give a second blow each time the drill is dropped. (See Fig. 7 for details.) To start drilling the tools are lowered down through the wooden tubes until stone is reached. The tools are suspended by a split bamboo rope from the short end of a lever arm, the rope is adjusted until the lever arm is horizontal with tools resting on bottom.

FIG. 8—DRILLING A WELL. THE LEVER ARM AND TOP OF DRILLING SET

To drill, the long arm of the lever is depressed by coolies, until the drill is lifted about a foot, when the arm is released and the drills drop. In this work a group of five or six men work on a scaffolding around the long lever arm; to depress the lever they put their right foot on the lever, which is carried down till it reaches the stops, when they step across to the bench opposite, thereby releasing the lever, which flies up, allowing the drills to drop. The movement of the lever is restricted in both directions by guide stops. The men then turn about and return, depressing the lever again. The lever is depressed as high as thirty times a minute, but fifteen to twenty would be nearer the average. Each time the drill raises the man at the well gives the rope a turn. One-half of the men who do the depressing of the lever cross in one direction while the others step in the opposite direction.

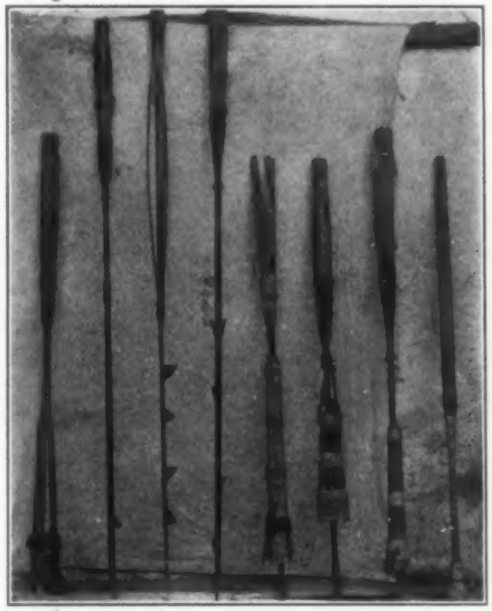


FIG. 9—TOOLS TO RECOVER LOST DRILLS, ETC.

The men work ten minutes then rest while the drill rope is being lengthened. Fig. 8 gives a good illustration of the arrangement of the drilling apparatus. The average drilling is 3 ft. in twenty-four hours. To drill an average 2500-ft. well six to twenty years is taken; three to five years only would be needed if the drilling were not interrupted by litigation, lack of capital, loss of tools and various other troubles. The average well takes ten years to become a producer.

The sand and dirt produced by the drilling is removed by the sand pump, a common bamboo tube 20 ft. long. To meet the emergency caused by breakage of rope and loss of tools, the Chinese have invented a wide variety of tools (see Fig. 9). If none of these tools accomplish the work, as a last recourse a new drill is let down and the lost articles slowly churned up. A lost bailer is treated in the same way.

At a well we visited the brine had given out at the 2600 ft. level, so they were drilling further. Since this well is a good average of the district the following data will be of interest:

Depth of drilling	2,600 ft.
Drop of drill per lift	10¾ in.
Drill size, Length	12 ft. 10 in.
Diameter	2¼ in.
Width of face	4¼ in.
Weight	160 catties or 208 lb.
Size of rope	three pieces of split bamboo, each piece ¼ x 1 in.
Rate of drilling—average	3.33 ft. per twenty-four hours
Number of men	working lever—5; at well—2
Lever arm, Short side	20 in.
Long side	15 ft., center of effort of men at 9 ft.

FIG. 10—TRANSPORTATION OF BRINE COOLIE CARRIAGE

FIG. 11—TRANSPORTATION OF BRINE. FLIGHT OF DRAGON BONE LIFTS

When drilling a well either gas or brine may be struck, but as both are valuable no one complains. A few of the wells yield a little petroleum, but no use is made of it, for it burns with too smokey a flame. No attempt is made to refine it. It is probable that deeper drilling would unlock untold wealth for the province.

A Chinese well operator estimated that the average cost of drilling a well is to

1,000 ft.	3,000 taels or $2,100 U. S.
2,000 ft.	7,000 taels or 4,900 U. S.
3,000 ft.	25,000 taels or 17,500 U. S.

It is surprising how accurate a Chinese is at arriving at an average. We have found that we could trust figures given as an average, even when the details are wrongly given.

Pumping or Drawing Brine

The brine obtained in the drilling is raised to the surface in bailers. These are bamboo tubes 60 to 110 ft. long and about 4 in. outside diameter. Each tube is made up of several bamboo tubes joined together by tapering ends. To prevent cracking and withstand the pressure, each tube is wrapped, for ½ in. in every 2 in., with hempen twine sunken below the surface. A tube holds about 650 lb. of brine. A bamboo rope made of three braided strands is used to pull the bailer up out of the well. See Fig. 5 for bailer.

The motive power for raising the bailer is of four kinds: (1) Human beings; (2) water buffalo; (3) donkeys; (4) steam engines.

1. *Human Beings.*—At some of the smaller wells sixty men and boys will be found slowly toiling to pull the bailer up. This is an old method, and at present rather goes against the grain of the Chinese to use it. The present year is the first time for over six years that it has been in use. The reason is that a very serious epidemic among the water buffalo has made these so scarce that only the wealthy wells can get them. During the epidemic last year one well lost seventy of its herd of 100 buffalo. Only beggars and orphans are used on this work; they get a place to sleep, one meal a day and 50 cash, or a cent and two-thirds for a day's work.

2. *Water Buffalo.*—The most common motive power is the water buffalo. From five to seven of these big lumbering beasts are hitched to the winding drum. As the bailer nears the top of the well, a rag on the rope is the indicator, and as the load lightens the drivers whip the beasts unmercifully to speed them up. This cruel treatment to a slow plodding animal causes short life. The animals last about four years on the average, when they are traded off for fresh animals. Some of the wells make eighty pulls a day; a pull requires the steady exertion of the buffalo for from ten to twenty minutes, according to the depth of the well. A set of buffalo make two turns of the wheel and then are given eight hours of rest and wallowing in the river. Thus the animal does about thirty minutes' work every eight or nine hours, night and day, as long as it lasts.

3. *Donkeys.*—A few wells use donkeys on the drum. Nine donkeys are used per shift. Ten shifts of animals are provided; each shift is used once and then rests until its next turn. They are a little quicker than the buffalo, but do not seem to be in much favor.

4. *Steam Engines.*—Some ten years ago an English salesman sold a well owner a steam engine to raise the brine. He reckoned five buffalo to be the same as 5 hp., so a 5-hp. engine was delivered. It lacked the needed power and was a flat failure. It has served as a terrible example at the hands of the old conservatives and the told-you-so's, and has discouraged the buying of more machines. About four years ago an engine of Chinese make was tried, and after lots of trouble it worked. Now there are several, mostly of Japanese make, in the territory.

The engines are used in two ways: first, a wire cable is wound around the old winding drum and carried over a pulley on the engine shaft, and the bailer is brought up by its bamboo rope in the old way; second, a half-inch steel cable is connected to the bailer and the cable wound up directly on the winding drum of the engine.

The best example of these engines now in use is a Japanese single-cylinder hoisting drum set with a separate boiler. The engine is a 12-in. stroke with a 7½-in. cylinder. It is rated at 25 hp., but was only developing

FIG. 12—TRANSPORTATION OF BRINE. BAMBOO PIPE LINES

13 when we saw it. The boiler was 4 by 10 ft., vertical fire tube, and could not supply enough steam for the work. The piping was too small, so there was a big loss in pressure from this source. This engine was making 150 pulls per day to eighty pulls when using buffalo. A pull took eight minutes as against twelve the old way; most of the lost time is due to waiting for the steam pressure to come up. There is a good field here for an enterprising company who will study the requirements of the work and aim to meet them with as cheap a set as possible.

A few years ago a gas engine was tried out, but an explosion in the gas bag due to back fire made it *persona non grata* with the Chinese. Although it did its work fairly well, we saw the dismantled engine being carried out of town last fall.

That we may gain some idea of the size of these wells, the following data, obtained at a well managed and representative well of the district, are given:

Name of well...................."Hong Hai Gin"—Red Sea Well
Depth of well..............2,600 ft. Chinese or 2,886 ft. English
Bailer—Bamboo....................3¼ in. O.D. and 2¾ in. I.D.
  Length ....105 ft. or 117 ft. English
  Contents..................520 catties or 676 lb. of brine
  Number of lifts per day..............................80
  Cost of bailer ....$12.50 U. S.
  Length of use..............one year, one spare on hand
  Foot valves...............cost 3 cents, use 15 per month
  Time taken per trip....up, 10 to 12 min.; down, 1½ min.

Bailer rope—Bamboo—1 in. in diameter of 3 strands, each strand made of 30 strips of split bamboo, each strip is 3/16 in. wide by 1/64 in. thick, thus 90 strips per rope. Each length of rope from 24 to 28 ft. long and costs 10 cents. Whole rope costs $12.00.
  A rope lasts 20 days and is replaced 5 lengths per day.

Winding drum—60 ft. circumference, 18 ft. diameter, 6 ft. high.
Buffalos—On drum per trip.................................. 5
  Total herd 80
  Original cost each animal..50 to 80 Taels or $35 to $56
  Used two, three to ten years, average 4 years, then traded in at about $15.00.
  Feed cost per day................14 cents each animal

Workers—2 shifts of 12 hours each.
  2 men each to cook, repair rope and let out brine.... 6
  9 men to feed and carry water for buffalo.......... 9
  24 men to drive buffalo.............................24
  3 foremen for men and 1 well boss................ 4
  7 office help at the well.......................... 7
  Help, total 50

Wages—Ordinary men ....2 to 3,000 cash or $2.30 a month
  Tube men—let out brine...3 to 4,000 cash or $2.70 a month
  Well boss ....5 to 6,000 cash or $3.00 a month

Production—Brine strength,
  2.4 oz. of salt per pound of brine or a 15% solution.
  Brine lifted per day.................27 tons, average
  Salt in above per day..............4.05 tons, average

Equipment Costs—Derrick, Drum, House, etc—Taels 4,000 or $2,800 U. S.

This well took over six years to drill and has been in active operation for over 100 years. It is the property of a wealthy clan.

From the above data we are enabled to work up a cost sheet of this well; the details follows:

FIG. 13—TRANSPORTATION OF BRINE. HORSE-DRIVEN WINDLASS AND BUCKET LIFTS

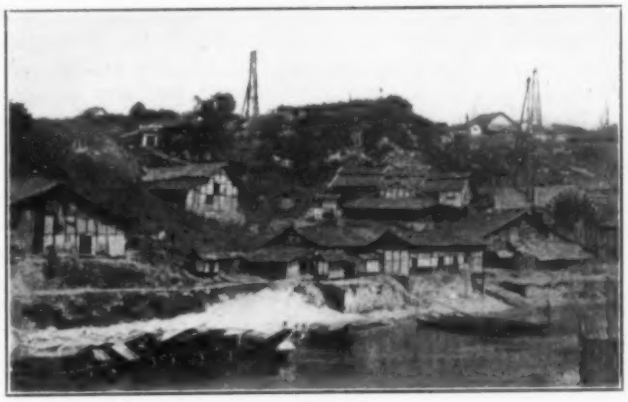


FIG. 14—TRANSPORTATION OF BRINE. LOADING BRINE BOATS

COST OF RAISING BRINE AT THE RED SEA WELL

Production per day			8,100 lb. of salt
Labor Charge:			Per Day
Feed for buffalo, 80, at $0.14 each			$11.20
Coolies' wages:			
1 at $3.00 per month		$3.00	
2 at $2.70 per month		5.40	
47 at $2.30 per month		108.10	
		$116.50/30	3.88
Animals Replacement Charge:			
Average use of a buffalo, 4 years, thus, with 80 animals, 20 are replaced per year.			
Purchase price	$45.00		
Traded in price	15.00	Loss is $30.00	
Thus 20 × $30.00 is $600.00/360			1.67
Materials:			
Repairs to rope, valves, tools, etc			1.00
			$17.75
Interest on Investment:			
Equipment	$2,800		
Buffalo	3,600		
Well value estimate	10,000		
	$16,400	at 10% is $1,640/360	4.56
Total manufacturing cost			$22.31
Office incidentals estimate			1.69
			$24.00

The manager of the well gave us these details, and also gave us Taels 50 or $35 as his estimate of the total daily running expenses of this well, including the office uptown.

From these figures it is seen that the cost of raising enough brine to give a pound of salt is 2400/8100, or 0.296 cents per pound or 11.5 cash per catty.

Transportation of Brine

When the bailer reaches the surface of the well the tubeman pushes it aside over a tub, and with an iron hook holds the foot valve up, the brine rushes out into the tub and flows away to the evaporating pans. (See Fig. 5.)

To get the brine to the evaporating pans use is made of gravity wherever possible. To this end bamboo tubes are placed end to end to make a pipe line. These pipe lines can be seen going up hills, through houses and sometimes under the river. It is hard to dig a foundation without striking either an active or an abandoned pipe line. All pipe lines lead to natural gas wells. When it is necessary to raise the brine beyond the level of its source the Chinese made use of several ingenious schemes.

Coolie Carriage.—One of the simplest of these schemes is to elevate a tank upon a platform and have coolies carry the brine up to it in buckets and empty them into the tank. (See Fig. 2, D. E. and Fig. 9.)

Dragon Bone Lift.—A very common type of lift for use on the hillsides is the dragon bone lift. This lift is in use by the farmers for irrigating the fields and lifting water to moderate heights. This machine resembles a wooden chain pump laid on its side. It

consists of a wooden jointed chain carrying thin oblong wooden vanes attached at right angles to the chain; the chain works in a long box open on the top and at both ends. The box is about 16 ft. long and has a cross-section of 6 in. deep by 10 in. wide. The chain with its vanes passes over a notched wheel at either end of the box. The upper wheel is turned either by a hand crank, by men working treadmill fashion, or by a gear and animals. The lower end of the box is placed in the brine and the traveling vanes entrap the liquid, which is carried up the box and discharged over the upper end. When the hill is high, cascades of five or more are needed. In this case each one is the feeder to the one which is above. (See Fig. 2, F. G. H. and Figs. 11 and 15.)

Windlass Lifts.—Sometimes an endless chain of buckets is arranged to lift from one level to another; sometimes it is one bucket only making an intermittent process. These are worked by hand crank, pulling or by horses through gears. (See Fig. 13.)

Compensated Bucket Lift.—From the long end of a lever a bucket is hung by a bamboo rope, while to the short end a stone that nearly compensates the weight of a full bucket of brine is tied. The fulcrum of the lever is on the top of a post and the rope passes down

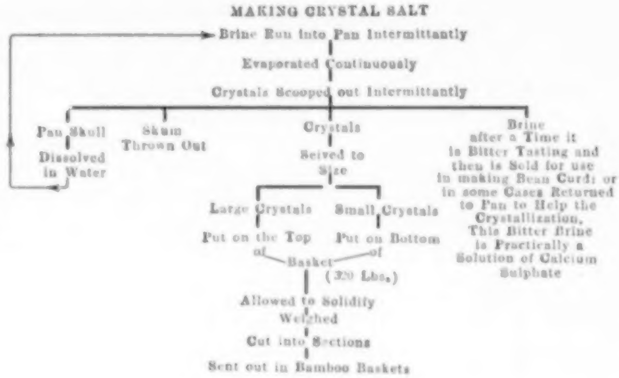
FLOW SHEET I

through the floor of the platform built over the tank. To lift the brine the bucket rope is pulled down until the bucket is filled in the lower tank, when the rope is pulled up and the bucket dumped at the higher level, 15 ft. above the tank. This scheme is also used to irrigate vegetable gardens from wells. (See Fig. 2, K, and in background of Fig. 10.)

Surge Tanks.—When the pipe lines are long and pass over wide valleys the pressure on the pipes is high, so a surge tank is placed at an elevation in the valley, slowing up the speed of the brine and easing up on the pressure. It is also found on the top of a hill where suction might cause the collapse of a tube. (See Fig. 2, J, and 12.)

All the pipes are bound with split bamboo, over a mixture of chalk and China wood oil, so that they are fairly satisfactory. They leak a little and it is no uncommon sight to see beggars digging up the salt-carrying earth under a pipe line and leaching it to get the salt. The pipe lines are rarely tampered with, for it is a criminal offense heavily punishable to disturb them.

In the part of the district where the brine has to be carried so far that the Chinese feel that a pipe line is too long, the brine is run into scows and poled up the river and unloaded. The dragon bone lift is used for



FLOW SHEET II

the unloading. (See Figs. 14 and 15.) The longest pipe line is about 7 miles.

Evaporation of Brine

The brine from the various wells is conducted to the vicinity of the gas wells and there evaporated in open pans over gas flames. The burners are rented to the owners of the brine, who furnish the workers and all the apparatus needed in the evaporating work. Two kinds of salt are made, the cake or pan salt and the crystallized.

The outlines of the process for making pan salt is given in Flowsheet I. The process for the production of the salt crystals is a little different. In the first place the pans are more carefully prepared for they are more permanent, after which the scheme given in Flowsheet II is used.

The iron pans used for the evaporating are shallow segments of a sphere 62 in. in diameter and 4 in. deep. The iron is 3 in. thick at the center and ½ in. thick at the edges. They are made of native cast iron and weigh from 1400 to 1600 lb. They cost 43 taels, or $30.10. When used for making pan salt they will last thirty or forty heats before cracking, and when repaired are good for as many more. As the usual heat is four days, they last nine months. The discarded pans are traded in for part payment for new pans. The fifteen iron side plates are in fact a detachable side rim 6 in. wide, and are used so that the salt cake can be easily removed. These fifteen sides cost about $9 a set and weigh 23 lb. each. In one evaporator house we visited there were 101 pans all making the salt cake. Fig. 16 shows a set of the pans and Fig. 2, N and O show

FIG. 15—TRANSPORTATION OF BRINE. UNLOADING BRINE BOATS

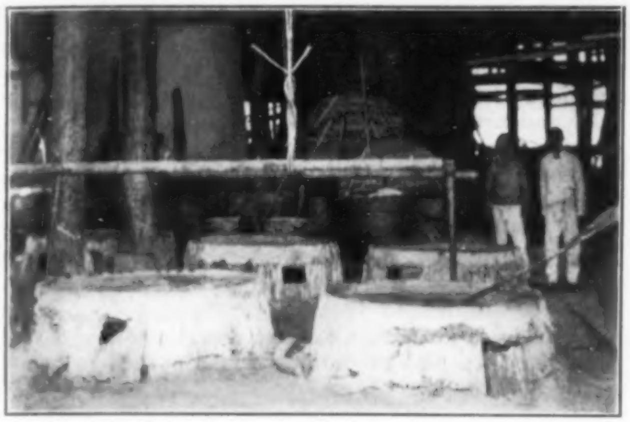


FIG. 16—EVAPORATION OF BRINE. SALT CAKE PANS

the construction for pan and crystal evaporation respectively.

When pan salt is made there is no attempt to get much draft under the pan—the leaks are plenty. The pan is set up on 2 x 2 x 10-in. stone legs and thin brick laid up around the edge to prevent the wind from blowing the gas flames. When making crystal salt the pan is set more permanently so a draft tube is provided at the back, while openings in the brick at the front provide for the needed regulation. (See Fig. 2, O.)

Gas Wells

The gas wells were originally driven for brine, but as they give off the gas, they are almost wholly used for the gas. To collect the gas a chamber of cement 7 ft. high and 10 ft. long is made around the well just below the ground and the wooden pipe cut out of this section. The gas arising collects in this chamber, the well is not capped as has been said, and no gas is smelled at the top, for the burners are situated 20 ft. higher than the level of the gas chamber and their burning sucks all the gas up the tubes. The gas pipes are 3-in. (inside diameter) bamboo tubes leading out of the top of the box. One well we were visiting served 200 burners, which were burning about 20,000 cu. ft. of gas per hour. When the brine rises and cuts off the gas supply a bailer is put down and the brine removed. This gives too much gas for a while and the pressure is relieved by lighting a big auxiliary torch, which serves as a safety valve. Fig. 16 shows such an auxiliary torch.

FIG. 17—NATURAL GAS WELLS—SURPLUS RELIEF BURNERS

The burners are made from bamboo tubes coated with a 2-in. layer of Chinese cement. Chinese cement is made from broken tile hammered fine, lime and sand or mud well mixed and hammered into place. Fig. 17 shows these burners, while Fig. 2, P and Q show the gas system.

The cost of evaporating is hard to calculate, but Sir A. Hosie estimates that it was 2 to 4 cash in 1884. (Report on province of Ssuch'uen, page 98.) The cost at the present time cannot be far from 4½ cash per gin or 0.15 cents per pound of salt.

If we add this value to the cost of raising the brine we have the following as the total cost of producing salt:

Raising brine............	11.5 cash per gin or 0.296 cents per pound
Evaporation	4.5 cash per gin or 0.150 cents per pound
	16.0 cash per gin or 0.446 cents per pound

Under the present uniform tax administered by the Salt Gabelle a hundred gin or 133 1/3 lb. of salt pay a tax of $2.50 silver. At an average of exchange of 1,500 cash per silver dollar this is 37.5 cash per gin or 0.967 cents per pound. Thus the salt at the place of production, duty paid, costs 53.5 cash per gin or 1.413 cents per pound. Fig. 18 shows the weighing of crystal salt at the tax office and its preparation for transport.

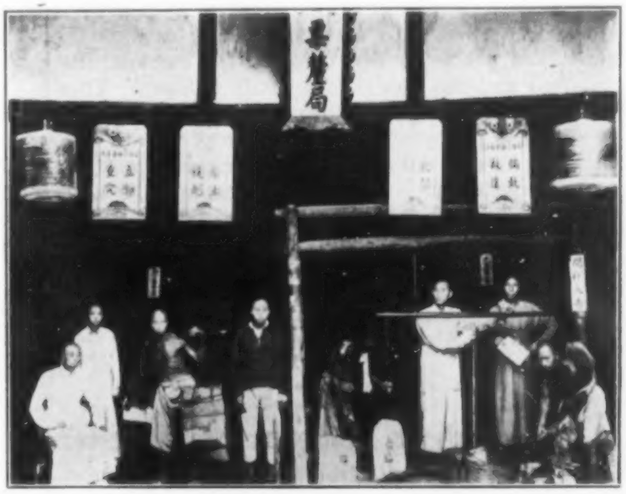


FIG. 18—INSPECTING AND WEIGHING CAKES OF SALT CRYSTALS. NOTE GOVERNMENT STAMP ON THE CAKE IN THE SCALE. NOTE OVERLAND COOLIE CARRIAGE OF THE SALT TO EAST AND WEST

Road transport by coolies costs 12 cents per 120 lb. per day of 25 miles, or one-tenth of a cent per pound per 25 miles. Chengtu the capital is 150 miles from the salt wells, and salt retails there for 80 cash a gin or 2 2/3 cents a pound. As the salt well gin has 18 oz. and the retail gin 16 oz., there is some chance for profit. The retail price of salt is fixed by the government for each locality.

It is said by the Chinese that there are 10,000 wells in the district. Of these 5000 are active and 500 in process of drilling, while the rest are abandoned or in litigation. In 1904 Tzuliutsing produced 183,000 of the 279,433 tons of salt credited to Szechuen by the salt office. The 1913 production for Szechuen is given as 367,246 tons, and if Tzuliutsing produced the same proportion as in 1904, the 1913 production would have been 244,830 tons.

Most of the wells are not large producers, probably not over 10 per cent of the active wells will produce as much as the representative "Red Sea Well." If the remaining 90 per cent had only a production of half a

ton the average of the whole lot of wells would be only three-quarters of a ton per day, thus the daily production of the district, 677 tons, would come from 900 wells, and the remainder of the 5000 wells would be producing less than nothing. It is thus evident that either the number of the wells is wrongly estimated by the Chinese or that a fewer number are active.

Some one discovered that a few of the wells were pumping from the same pocket, so when the wells ran dry, water was run down into the deepest well, a 2500-foot well, and now twenty-three wells in an area of a square mile can be pumped. At present about 150 gal. of water a minute is run into this well for half a day at a time. Thirteen of the wells can pump continuously from the water thus supplied. In order that the owners of the pumping wells can be sure that they are getting what they pay for, rice hulls are fed in with the water into the big well.

The stopping of leaks in the well shows the ingenuity of the Chinese. When a fresh water leak threatens to impair the usefulness of the well, its location is ascertained, then a bunch of coarse grass is rammed down below the position of the leak. On to this grass a mixture of mud, lime and China wood oil is poured; this is allowed to harden to a cement. The drill is then put down and a hole drilled through the cement, the grass removed and the leak is effectually stopped. This is the same method which has been lately advised to be used in stopping the waste of natural gas from oil wells. One who thinks that all progress in technical matters is associated with the Anglo-Saxon race, will be very much surprised at the development reached in this district some thousand years ago. The trip is well worth its cost.

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Electrolytic Behavior of Tungsten*

By Walter E. Koerner

The electrolytic behavior of tungsten has not been extensively investigated. Almost all of the earlier investigators have worked on the electrolytic deposition of metallic tungsten, their object being probably to produce tungsten in a tangible form by a relatively simple method.

The first researches upon the electrolytic reduction of tungsten were made from solutions of fused baths of tungstates. Zettnow[1], in an article published in 1867, describes a black amorphous powder of metallic tungsten which he obtained, along with sodium bronze, by the electrolysis of molten sodium tungstate. Hallopeau[2], obtained by the electrolysis of molten lithium paratungstate, with platinum electrodes, crystals of metallic tungsten. Stavenhagen[3], however, under the same conditions, obtained no metallic tungsten, but only lithium tungsten bronze. Scheibler[4] and Knorre[5] describe in their papers a large number of tungsten bronzes which they obtained by the electrolysis of molten tungstates.

Martin[6] obtained impure metallic tungsten by the electrolysis of tungstic acid dissolved in molten cryolite, analogous to the method of preparing metallic aluminium. The electrolysis of molten baths of halogen or oxyhalogen compounds of tungsten is not feasible as these compounds are not very good conductors.

*A paper presented at the New York Meeting of the American Electrochemical Society on September 8, 1916.

[1] See p. 47 for all references.

Little is known about the electrolysis of aqueous and non-aqueous solutions of tungstates. Smith[7] observed that no effect is produced by the electrolysis of neutral solutions of tungstates, but that in acid solutions a blue color and a blue precipitate (presumably W_2O_5) is produced. The blue compound changes to brown as the current is allowed to run for some time. When the compound is exposed to the air after electrolysis, the brown changes back to blue.

The author does not agree entirely with Smith. He not only obtained the blue and brown compounds described by Smith, by the electrolysis of sodium tungstate acidified with H_2SO_4, but he also obtained a blue solution and a blue precipitate which turned to brown by the electrolysis of sodium tungstate in a neutral solution. The conditions, however, were somewhat different. Smith used platinum electrodes, while the author used tungsten electrodes.

Leiser[8] electrolyzed an acid solution of sodium tungstate between a nickel anode and a platinum cathode, and obtained a blue precipitate which when analyzed was found to be W_4O_{11}. With a lead cathode he obtained a brown deposit which probably was WO_2.

Rosenheim[9] electrolyzed a solution of H_2WO_4 in an alcoholic solution of HCl (gas). H_2WO_4 dissolves in this solution to the extent of 9.8 per cent H_2WO_4. He used graphite as anode material. With a platinum cathode the reduction proceeded only as far as pentavalent tungsten (W^{v}). With mercury or cadmium cathodes, the reduction varied with the current density, while with zinc cathodes, the reduction proceeds to tetra valent tungsten (W^{iv}). Rosenheim obtained a series of oxides of tungsten varying in valence from five to two. He obtained no metallic tungsten.

Up to this date, 1909, no satisfactory method had been developed for the electrolytic deposition of tungsten and no metallic tungsten had been obtained.

In June, 1910, a patent[10] was issued in Germany for the electrolytic deposition of metallic tungsten from an aqueous or organic solution of pertungstic acid, H_2WO_5, or one of its salts.

In the same month of the same year, a second patent[11] was issued to the Wolfram-Lampen A.G. for the electrolytic deposition of tungsten from organic solutions of WCl_6.

Fischer[12] tried to deposit metallic tungsten from solutions of WCl_6 in absolute ethyl alcohol saturated with HCl (gas) and from solutions of WCl_6 in glycerine. With the latter the concentration of the dissolved WCl_6 was too small for practical observations. Fischer used carbon as anode and platinum as cathode in his work. With a low concentration of WCl_6 (3 gm/150 c.c. of alcohol), he obtained a green solution, the green color being due to a reduction to penta valent tungsten. He[13] found this green color to be due to a triethoxyl substitution product of tungsten pentachloride, $WCl_2(OC_2H_5)_3$.

With a higher concentration (22 grams of WCl_6 per 120 c.c. of alcohol) he obtained, on the cathode, a black precipitate which could not be strictly called tungsten metal. He decided that it was WO.

Fischer tried also to obtain tungsten by the method described by other German patents[14] but without success. He obtained by the electrolysis of pertungstic acid, a blue-black precipitate which when analyzed showed 92.33 per cent tungsten. This corresponds to WO.

It seems, in going over the literature, that although some of the earlier investigators thought that they had produced metallic tungsten by electrolysis, in nearly every case the precipitate obtained was some tungsten

compound, principally WO and perhaps a lower oxide. Fischer tried to verify the claims made by the German patents, but he obtained no pure metal.

The work on the electrolytic behavior of tungsten which the author here presents in a preliminary report, was divided into four sub-heads.

1. Single potentials E. P. of tungsten:
   - A. E.P. of tungsten in various electrolytes.
   - B. E.P. of tungsten in saturated solutions of tungsten hydroxide in various electrolytes, bearing on the solubility of tungsten oxide.
2. The anodic behavior of tungsten and passivity:
   - A. In acids, and in neutral salt solutions in water.
   - B. In acids, and in neutral salt solutions in organic solvents.
   - C. In inorganic and organic alkalies with a bearing on the electrolytic recovery of tungsten.
3. A. The use of tungsten in a voltaic cell.
   - B. The use of tungsten in a standard cell.
   - C. The use of tungsten in a storage cell.
4. The author has reserved all observations made on the electrolytic deposition of tungsten for future publication.

Single Potentials of Tungsten

The single potential measurements were made in order to obtain some light on the relative solubility of tungsten in solutions of various electrolytes.

Insoluble electrodes give single potentials of the positive and negative ions in solution. In a 1/1 n. NaOH solution we should get, if the anode were insoluble, the value of the oxygen electrode, 1.47 V (H = O). The single potential for tungsten in 1/1 n. NaOH solution is —0.316 V (H = O), a value very much smaller than the oxygen potential. It follows, then, that the tungsten anode goes into solution in NaOH and ionizes. The rate of solution varies with the solvent used.

Three half cells were used as auxiliary electrodes in measuring the single potentials. The first, the normal KCl-calomel half cell, was used with acid and salt solutions. The second, a half cell made from Hg, red HgO and 1/1 n NaOH was used with alkali solutions. The third, a half cell made from Ag, Ag_2O and 1/1 n NaOH was used as a check on the other two cells.

The 1/1 n KCl-calomel electrode was made according to standard specifications.[16] The single potential of this electrode was taken as +0.56 volts. The potential of the second cell, made with the same construction as the first, but having HgO substituted for HgCl, and 1/1 n NaOH substituted for KCl, was taken as +0.445 volt[17]. The third cell, made from Ag, Ag_2O and 1/1 n NaOH was taken as +0.655 volt[18]. The cells were checked up against each other and found to agree within amounts not greater than those allowed for experimental error.

In the combination,

$$\mathrm{Hg} \mid \mathrm{HgCl} \mid \mathrm{KCl} \parallel \mathrm{NaOH} \mid \mathrm{HgO} \mid \mathrm{Hg}$$

the emf. obtained was 0.1588 volt with the mercury in the calomel, positive. If the single potential of the calomel electrode is +0.56 and that of the mercury oxide electrode is +0.445 V., the emf. produced by the combination, neglecting the liquid potential KCl | NaOH should be +0.115 volt. Since we get an emf. of 0.1588 volt, we conclude that the liquid potential KCl | NaOH is +0.0438 volt.

Similarly with the combination,

$$\mathrm{Ag} \mid \mathrm{Ag_2O} \mid \mathrm{NaOH} \parallel \mathrm{KCl} \mid \mathrm{HgCl} \mid \mathrm{Hg}$$

(the silver being positive) we get an emf. of +0.0488 volt. The value of the liquid potential KCl | NaOH is calculated to be in this case +0.0462 volt.

$$+0.655 + x + (-0.56) = 0.0488$$
$$x = -0.0462$$
$$x = \mathrm{NaOH} \mid \mathrm{KCl} = -0.0462$$

then $\quad -x = \mathrm{KCl} \mid \mathrm{NaOH} = +0.0462.$

Finally in the combination,

$$\mathrm{Ag} \mid \mathrm{Ag_2O} \mid \mathrm{NaOH} \parallel \mathrm{NaOH} \mid \mathrm{HgO} \mid \mathrm{Hg}$$

with silver positive, the emf. obtained was 0.209 volt. This checks up with 0.210 volt = [+655 + (—0.445)].

The tungsten electrodes used in these measurements were 75 mm. long and 3.2 mm. in diameter. They were made from a high-grade tungstic acid which was reduced to tungsten metal by hydrogen. The metal powder was pressed into a rod at a high pressure and melted electrically in hydrogen. After cooling in the same gas, the rod was hot swaged to size, cut in half, and two electrodes of the same composition obtained.

Before making the choice of this form of tungsten metal, we made several single potential measurements with different kinds of so-called tungsten metal, made by different processes. It was found that the potential of these various metals in 1/1 n NaOH varied within wide limits. A black finely divided metal powder had a single potential of —0.704 volt (H = O), while gray compact melted rod had a single potential (E.P.) of —0.316 volt (H = O). See Table I.

Upon closer and further observations we concluded that the finely divided black metal contained a lower form of oxide, either as a mechanical mixture, or adsorbed to, and covering the metal particles. The high E.P. in this case is not the W | NaOH potential, but the E.P. of W_xO_y | NaOH. Tungsten oxides are more soluble in NaOH than W and have higher E.P.'s in NaOH than tungsten.

Following is a table showing the emf.'s as measured with the Hg | HgO | NaOH electrode, of various forms of tungsten metal. The E.P.'s are expressed in terms of calomel = O, calomel = +0.56 and hydrogen = O.

TABLE I

1 Form of Metal	2 E.M.F.	3 E.P. Cal=0	4 E.P. H=0	5 E. P. Cal=+0.56
	Volts	Volts	Volts	Volts
Black powder	+0.872	−0.987	−0.704	−0.427
Grey powder	+0.776	−0.891	−0.608	−0.331
At. Wt. powder	+0.667	−0.782	−0.499	−0.222
Rod No. 1	+0.573	−0.688	−0.405	−0.128
Rod No. 2	+0.561	−0.676	−0.393	−0.116
Rod No. 3	+0.494	−0.609	−0.326	−0.049
At. Wt. rod	+0.484	−0.599	−0.316	−0.039

Column 2 in Table I gives the emf. values as actually measured. They may also be taken as E.P.'s of NaOH | W when the value of the auxiliary electrode is taken as zero. The E. P.'s of W | NaOH would be the same values numerically, but opposite in sign.

It was suggested, at the International Congress of Berlin[19], that in all cases the directly measured values be given and that the 1/1 n KCl calomel or the Nernst hydrogen electrodes be employed as auxiliary electrodes and taken as zero. These direct measurements may be taken as the E.P.'s of the combinations referred to the calomel or hydrogen electrodes as zero. (Cal = O) (H = O). Since we used the HgO half cell (already described) as the auxiliary electrode, it is necessary to calculate to the calomel values. The relation of calomel to mercury oxide is,

$$\text{E.P. Cal} = \text{HgO} + 0.115 \text{ volt.}$$

It follows that in order to change the HgO values to calomel values, it is only necessary to add 0.115 volt to the emf. readings and change the signs to reduce these to W | NaOH. These E. P.'s are shown in column 3.

A relation also exists between the E.P. of the hydrogen electrode and that of the calomel electrode. This relation[20] is expressed by

$$\mathrm{EP}_H = \mathrm{EP}_{cal} + 0.283 \text{ volt.}$$

Column 4 gives the E.P.'s of W | NaOH compared to H = O.

Column 5 gives the values in terms of Cal = +0.56 volt.

The emf.s' given in Table I and the following tables were obtained by means of a Wolff potentiometer connected, with a standard Weston element, to a small storage cell to furnish current and a D'Arsonval galvanometer. After compensating the standard Weston element and the storage cell, the potentiometer was adjusted to zero swing on the galvanometer. The emf. was read directly from the potentiometer.

The customary precautions were taken in connecting up the cells to prevent the different electrolytes from mixing. Glass U tubes 80 mm. long and 2 mm. bore through which clean cotton cord was passed, served to connect one electrolyte with another. In some cases, a cup containing the same electrolyte as the one in which the tungsten was immersed, was interposed between the latter and the cup containing the second electrolyte. This was to further reduce the contamination of the first electrolyte with the second.

Table II gives the results obtained with W in the various electrolytes used.

In Table II, column 1 gives the 1/1 n acid solutions in which the tungsten rod was immersed. Column 2 gives the emf.'s measured with the calomel electrode as an auxiliary electrode. Column 3 shows the calculated E.P.'s of W | sol compared to calomel = +0.56 volt, disregarding liquid potential KCl | acid sol. Column 4 gives the E.P.'s KCl | acid sol. calculated from Planck's formula $\left[EP = 1.99 \times 10^{-4} T \log \left(\frac{U_1 + V_2}{U_2 + V_1} \right) \right]$. Column 5 shows the E.P.'s W | sol. corrected for liquid potential KCl | acid sol. (calomel = +0.56 volt). Column 6 gives the E.P.'s for W | sol. compared to calomel = O not corrected for liquid potentials, while column 7 gives the E.P.'s for W | sol. cal = O corrected for E.P.'s KCl | acid sol. Column 8 gives the E.P.'s for W | sol. compared to H = O.

Table II—1/1 n Acids—Measured with Auxiliary Electrode Hg/HgCl/KCl = +.56 V

1 1/1 n Acid	2 E.M.F.	3 E.P. W/sol Cal = +0.56 V.	4 E.P. KCl/Sol	5 E.P. W/sol Corrected Cal = +0.56	6 E.P. W/sol Cal = 0	7 E.P. W/sol Corrected Cal = 0	8 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts	Volts
H_2SO_4	+0.060	+0.500	−0.030	+0.470	−0.060	−0.039	+0.193
HCl	−0.0028	+0.562	−0.029	+0.533	+0.0028	−0.027	+0.256
HNO_3	−0.057	+0.617	−0.029	+0.588	+0.057	+0.028	+0.311

Table IIIA—1/1 n Bases—Measured with Auxiliary Electrode Hg/HgO/NaOH = +0.445

1 1/1 n Base	2 E.M.F.	3 E.P. W/sol HgO = +0.445	4 E.P. HgO/sol.	5 E.P. W/sol Corrected HgO = +0.445	6 E.P. W/sol Cal = 0	7 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KOH	+0.481	−0.036	−0.002	−0.038	−0.598	−0.315
NaOH	+0.484	−0.039	0	−0.039	−0.599	−0.316
NH_4OH	+0.406	+0.039	——	+0.039	−0.521	−0.238
KCN	+0.715	−0.370	——	−0.370	−0.930	−0.647

Table IIIB—1/1 n Bases—Measured with the Auxiliary Electrode Ag/Ag_2O/NaOH = +0.655

1 1/1 n Base	2 E.M.F.	3 E.P. W/sol HgO = +0.445	4 E.P. HgO/sol.	5 E.P. W/sol Corrected HgO = +0.445	6 E.P. W/sol Cal = 0	7 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KOH	+0.690	−0.035	−0.002	−0.037	−0.597	−0.314
NaOH	+0.694	−0.039	0	−0.039	−0.599	−0.316
NH_4OH	+0.615	+0.040	——	+0.040	−0.520	−0.237
KCN	+1.034	−0.379	——	−0.379	−0.939	−0.656

Table IIIC—1/1 n Bases—Measured with the Auxiliary Electrode Hg/HgCl/KCl = +0.56

1 1/1 n Base	2 E.M.F.	3 E.P. W/sol Cal = +0.56	4 E.P. KCl.NaOH	5 E.P. W/sol Corrected Cal = +0.56	6 E.P. W/sol Cal = 0	7 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
NaOH	+0.648	−0.088	−0.048	−0.040	−0.630	−0.317

Table IV—Halogen Salts 1/1 n—Measured with the Auxiliary Electrode Hg/HgCl/KCL = +0.56

1 Salt	2 E.M.F.	3 E.P. W|sol Cal = +0.56	4 E.P. KCl/sol	5 E.P. W/sol Corrected Cal = +0.56	6 E.P. W/sol Cal = 0	7 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
KF	+0.235	+0.325	−0.0037	+0.2213	+0.239	+0.522
KCl	+0.280	+0.280	0.000	+0.280	+0.280	+0.563
KBr	+0.306	+0.264	+0.0004	+0.264	+0.306	+0.589
KI	+0.450	+0.11	+0.0002	+0.11002	+0.450	+0.733

Table V—K Salts of Acids of Table II—Measured with the Auxiliary Electrode Hg/HgCl/KCl = +0.56 V.

1 Salt	2 E.M.F.	3 E.P. W/sol Cal = +0.56	4 E.P. KCl/sol.	5 E.P. W/sol Corrected Cal = +0.56	6 E.P. W/sol Cal = 0	7 E.P. W/sol H = 0
	Volts	Volts	Volts	Volts	Volts	Volts
K_2SO_4	+0.430	+0.130	−0.006	+0.124	+0.436	+0.719
KCl	+0.280	+0.280	0.000	+0.280	+0.280	+0.563
KNO_3	+0.017	+0.593	−0.0007	+0.544	+0.017	+0.300

Table III gives the same results for bases as Table II gives for acid. In this case the auxiliary electrode Hg | HgO | NaOH = +0.445 volt was used. Column 5 gives the E.P. W | sol. compared to HgO = +0.445. These values are identical to E.P. W | sol. compared to cal. = +0.56. From these figures the E.P. W | sol. values compared to cal. = O are obtained and given in column 6. The E.P.'s W | sol. H = O are shown in column 7.

Tables III-b and III-c are practically the same except that in the former case we used the silver oxide electrode, while in the latter we used the calomel electrode. Table IV gives the results obtained with 1/1 n solution of the halogen salts of K, and table V, the results obtained with K salts of the acids shown in Table II.

It is seen from Table II that the E.P. W | 1/1 n acid sol. varies with the acid used, and that it is highest with HNO_3 and lowest with H_2SO_4. Tables III-a, III-b, and III-c show that with KOH and NaOH the E.P.'s are practically the same, while with NH_4OH the E.P. is lower numerically and higher algebraically than those of NaOH or KOH. The E.P. of W | KCN is much higher numerically (and lower algebraically) than any of the others. Tables IV and V show the E.P. for W | sol. in the various salts.

The potential of tungsten in 1/1 n HNO_3 may be compared to the potential of copper in 1/1 n (ion concentration) $CuCl_2$ solution. The E.P. of Cu | $CuCl_2$ is +0.329 volt (H = O)[2], while that of As | $AsCl_3$ is +0.293 volt (H = O).

The potential of W in the alkalies may be compared in the same way, that of W in KCN being higher than that of iron but lower than that of nickel; the potential of W in NaOH, KOH and NH_4OH being higher than that of thallium, but lower than that of tin. In like manner the potentials of W in the halogen and other

TABLE VI

1	2 E.P. W/sol H=0	3 E.P. H=0 Le Blanc	4
	Volts	Volts	
		−0.660	Fe
KCN	−0.647		
		−0.610	Ni
		−0.322	Tl
NaOH	−0.316		
KOH	−0.315		
NH_4OH	−0.238		
		−0.192	Sn
		−0.148	Pb
		0	H
H_2SO_4	+0.193		
HCl	+0.256		
		+0.293	As
KNO_3	+0.300		
HNO_3	+0.311		
		+0.329	Cu
		+0.466	Sb
KF	+0.522		
KCl	+0.563		
KBr	+0.589		
K_2SO_4	+0.719		
KI	+0.733		
		+0.750	Hg

salts can be compared with the potentials of other metals.

We have arranged a relative potential table in order of increasing E.P. algebraically from the lowest algebraic value to the highest algebraic value. See Table VI. In column 2 are given the E.P.'s of W | sol. calculated from the measurements taken. Column 3 gives the E.P.'s for Fe, Ni, Tl, etc., taken from Le Blanc.

It was not possible to determine the E.P. of tungsten in aqueous solutions of its salts, because the salts of tungsten, *e.g.*, the hexachloride and hexabromide, are readily decomposed by water. Fischer[22] and others have found that WCl_6 dissolves very readily in many organic solvents without decomposition, and that some of the solutions are quite conducting. Fischer chose, as a specific solvent, absolute ethyl alcohol, and measured the E.P. of W | WCl_6 in solutions of varying concentrations of WCl_6, using, as an auxiliary electrode, a calomel half cell, the electrolyte of which was a saturated solution of lithium chloride in alcohol. He found that a 0.102 n (molecular) solution of WCl_6 produced, along with the auxiliary half cell, an emf. of 0.465 volt, the tungsten being positive. From this value he calculated the E.P. of W | 1/1 n (ionic) sol. WCl_6 to be 0.680* volt (H = O). He also calculated the E. P. $H_2O - C_2H_5OH$ to be 0.071 volt. He assumes that

$$\text{EP W} - WCl_6(C_2H_5OH) - \text{EP } H_2O - C_2H_5OH = \text{EP W} - WCl_6(H_2O)$$

and substituting the values obtained above he gets

$$\text{EP W} - WCl_6(H_2O) = 0.609 \text{ volt}^* \ (H = O)$$

a hypothetical value. He decides that W lies between Sb and Hg in the electrochemical series given by Le Blanc.

Analogous to Fischer's experiments, we thought it possible to find the E.P. of W in saturated solutions of $W(OH)_6$ in 1/1 n HCl, H_2SO_4 and HNO_3, and from the E.P.'s obtained to calculate the E.P.'s in 1/1 n (ionic) solution of $W(OH)_6$. The solutions of $W(OH)_6$ were prepared by electrolyzing the solvents between tungsten electrodes until a copious excess of yellow precipitate was obtained. The anode during electrolysis in each case went through a series of color changes from brown through blue to yellow, after which tungstic acid was precipitated from the solution. These color changes will be discussed later. We considered the solvents saturated with $W(OH)_6$ when the precipitate began to form. The reactions which take place at the anode during electrolysis produce a hydroxide of tungsten, which dissolves to saturation and ionizes. When the solvent is saturated with ions, the molecular $W(OH)_6$, being unstable, breaks down to H_2WO_4 and analogous compounds by the loss of water. The reactions expressing these changes being,

$$W(OH)_6 = WO(OH)_4 + H_2O$$
$$W(OH)_6 = WO_2(OH)_2 + 2H_2O$$
$$W(OH)_6 = WO_3 + 3H_2O$$

The end product, anhydrous WO_3, is probably never reached in this case.

Analogous reactions occur between ionic chlorine and tungsten. Tungsten hexachloride forms and dissolves. Being unstable in water, it immediately decomposes to $W(OH)_6$.

$$WCl_6 + 6H_2O = W(OH)_6 + 6HCl$$

$W(OH)_6$ dissolves to saturation and the excess breaks down to WO_3 in the same manner as in the above case. In case either Cl ions or OH ions are discharged at the anode, the end products will be the same. Analogous reactions occur in HNO_3 and H_2SO_4 solutions.

That W and Cl ions do unite to form WCl_6 has been shown by electrolyzing a saturated solution of HCl (gas) in absolute ethyl alcohol between tungsten electrodes which have been separated by a porous cup. The anode solution becomes colored yellow by the dissolved WCl_6 that has been formed.

Our emf. measurements, Table IX, have shown that $W(OH)_6$ is not only soluble in 1/1 n HCl, H_2SO_4 and HNO_3, but also that the $W(OH)_6$ is ionized to W ions and OH ions. It is dissolved as a true solution and not a colloidal solution, though some collodial tungstic acid may be present in the solution. Unless the $W(OH)_6$ were ionized, no emf. would have been obtained in the combination,

$$W \left| \begin{array}{l} W(OH)_6 \\ HCL \end{array} \right\| HCl \,|\, W \quad \text{(See Table IX.)}$$

We have assumed that the dissolved tungsten is present as a hydroxide, $W(OH)_6$, and that this hydroxide ionizes to W ions and OH ions in the same manner that $Pb(OH)_4$ ionizes to Pb ions and OH ions in the lead accumulator.[23-24] According to Dolezalak,[24] PbO_2 hydrolyzes to $Pb(OH)_4$, which ionizes to a tetravalent lead ion and four OH ions.

If $W(OH)_6$ is an amphoteric electrolyte,[25] the tungsten in solution must migrate as cations to the cathode in acid solution, and as anions to the anions in alkaline solution.[26]

From direct measurements, the combination

$$W \left| \begin{array}{l} H_2SO_4 \\ W(OH)_6 \end{array} \right\| H_2SO_4 \,|\, W$$

gave an emf. of +0.117 volt with the tungsten in the $W(OH)_6$ as positive. This shows that the half cell $W \left| \begin{array}{l} W(OH)_6 \\ H_2SO_4 \end{array} \right.$ is 0.117 volt more positive than the half cell in which there is no $W(OH)_6$ in solution. The combination is a concentration cell, the right-hand member being the more dilute with respect to $W(OH)_6$.

According to Nernst,[27] the dilute solution always presents the sign of the more rapidly moving ion. It is obvious that the mobility of the OH ion is much greater than that of the W ion. The more dilute solution will then be negative to the more concentrated with respect to $W(OH)_6$. The concentration of the H and the SO_4 ions are approximately the same in both half cells.

If instead of having $W(OH)_6$ in solution, we had paratungstic acid, $H_6W_7O_{24}$, or ortho tungstic acid, H_2WO_4, we would have WO_4 ions and an increased number of H ions in the right-hand half cell (assuming H_2WO_4 dissolved). Since the H ion is more mobile than the WO_4 ion, the more dilute solution would then be positive. Experiment showed, however, that the more dilute solution is negative, taking the sign of the more mobile of the ions resulting from the dissociation of

*Fisher has confused his signs in his calculations.

the $W(OH)_6$. Tungsten must then exist as the cation in solution, and the solution must contain $W(OH)_6$.

Tables VII, VIII and IX give the results of the experiment.

Table VII—1/1 n Acids, no $W(OH)_6$ Added—Measured with Auxiliary Cal Electrode = +0.56 V.

1	2	3	4	5	6	7	8
1/1 n Acid	E.M.F.	E.P. W/sol cal= +0.56	E.P. KCl /sol	E.P. W/sol Corrected cal= +0.56	E.P. W/sol cal=0	E.P. W/sol Corrected cal=0	E.P. W/sol H=0
	Volts	Volts	Volts	Volts	Volts	Volts	Volts
H_2SO_4	+0.058	+0.502	−0.030	+0.472	−0.058	−0.088	+0.195
HCl	−0.006	+0.566	−0.029	+0.537	+0.006	−0.023	+0.260
HNO_3	−0.054	+0.614	−0.029	+0.585	+0.054	+0.025	+0.308

Table VIII—1/1 n Acids Sat. with $W(OH)_6$.—Measured with Auxiliary Cal. Electrode = +0.56 V.

1	2	3	4	5	6	7	8
1/1 n Acid	E.M.F.	E.P. W/sol cal= +0.56	E.P. KCl /sol	E.P. W/sol Corrected cal= +0.56	E.P. W/sol cal=0	E.P. W/sol Corrected cal=0	E.P. W/sol H=0
	Volts	Volts	Volts	Volts	Volts	Volts	Volts
H_2SO_4	−0.06	+0.620	−0.030	+0.590	+0.06	+0.030	+0.313
HCl	+0.063	+0.623	−0.029	+0.594	+0.063	+0.034	+0.317
HNO_3	+0.063	+0.623	−0.029	+0.594	+0.063	+0.034	+0.317

Table IX—Half Cell Combinations

$+W/H_2SO_4\ W(OH)_6 \parallel H_2SO_4/W-$	+0.117 volts
$+W/HCl\ W(OH)_6 \parallel HCl/W-$	+0.057 volts
$+W/HNO_3\ W(OH)_6 \parallel HNO_3/W-$	+0.009 volts

In Table VII the E.P.'s of W in N acid sol. are shown. Table VIII shows the E.P.'s of W in N acid solutions saturated with $W(OH)_6$. Table IX shows the order of solubility of $W(OH)_6$ in the three acids. It is least soluble in HNO_3 and most soluble in H_2SO_4. In each of the three cases the e.m.f. is the result of the difference of concentrations in the two members of the cell. The concentrations of $W(OH)_6$ in the right hand members are very small. We determined the amount of $W(OH)_6$ that is dissolved in the three 1/1 N acid solutions to saturation by evaporating a large volume of the solution to dryness, igniting and weighing as WO_3. We find

0.02281 gm. WO_3 [= 0.02816 gm. $W(OH)_6$] per 1000 c.c. n/n H_2SO_4

0.01067 gm. WO_3 [= 0.01315 gm. $W(OH)_6$] per 1000 c.c. n/n HCl

0.00025 gm. WO_3 [= 0.00030 gm. $W(OH)_6$] per 1000 c.c. n/n HNO_3

If we try to calculate the concentration of the $W(OH)_6$ in solution by means of the modified Nernst formula

$$EP = \frac{0.058}{V} \log \left(\frac{C_1}{C_2} \right)$$

Where C_1 and C_2 are the ionic concentration, we run into difficulties. We cannot calculate the concentration of $W(OH)_6$ from conductivity measurements because the conductivity of the 1/1 n acid solutions are so high and the concentration of the $W(OH)_6$ is so low that the increase in conductivity due to $W(OH)_6$ would not be much greater than a value due to experimental error.

From the values of concentration found by evaporating to dryness, we can calculate the E.P. for W | 1/1 n $W(OH)_6$

$$EP_n = EP - \frac{0.058}{v} \log c$$

This was found to be +0.336 volt in n H_2SO_4, +0.342 volt in n HCl and 0.358 volt in n HNO_3.

Anodic Behavior of Tungsten in Electrolytes

Le Blanc[22] studied the anodic behavior of tungsten in various electrolytes, and found that in 1/1 n solutions of H_2SO_4, HCl and HNO_3 the metal becomes passive. In KOH, NH_4OH, NaOH, however, he found that the metal stays active within wide ranges of current density. If, however, the current density reaches or exceeds a maximum in alkaline solutions, tungsten becomes passive. Interrupting the current for a short time destroys the passivity.

From experiments which we have made, we have noticed that when 1/1 n solution of HCl, H_2SO_4, HNO_3, KF, KCl, KBr, KI, K_2SO_4 and KNO_3 are electrolyzed between tungsten electrodes separated by a porous cell, the anode always becomes coated with a series of films ranging in color from brown through purple, dark blues, light blues, greens, to yellow. The color changes are *independent* of the nature of the anions and cations in the solution used, but are *dependent* upon the current density and the time of electrolysis.

With an initial current density of approximately 0.00025 ampere per square dm., the color changes of the film on the anode can be very easily followed. I use the term initial current density to denote the current at the start. As the electrolysis proceeds, the resistance of the film increases and the current flowing is decreased. The first flash of brown color is quite marked and the change from brown to purple is also quite marked. The change to dark blue and to light blues is slower, and it is difficult to tell when the greens stop and the yellow begins. The change from green to yellow is gradual. These changes are a function of current density and time. Tables XI, XII, XIII give some comparative figures on three runs which we made with a 1/1 n solution of KCl.

If the initial current density be increased to 2 amp. per dm^2, the anode assumes a yellow color almost immediately. The eye, not being quick enough to follow the color change from brown to yellow, sees only the yellow.

Table XI

Time, Sec	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	Gray (tungsten)
2	0.0400	1.325	Brown
5	......	1.350	Purple-brown
7	......	1.350	Purple
10	......	1.350	Dark blue
12	......	1.375	Light blue
20	0.0270	1.425	Green blue
30	0.0225	1.460	Olive green
60	0.0175	1.480	Yellow green
80	0.0165	1.50	Yellow
100	0.0150	1.54	Yellow

Table XII

Time, Sec.	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	
2	0.065	1.0	Brown
5	....	1.1	Purple-brown
7	......	1.1	Light blue
10	0.035	1.15	Light blue
15	......	1.225	Green blue
20	0.028	1.25	Yellow-green
30	0.025	1.325	Yellow

Table XIII

Time, Sec.	Current, Amp.	Back E.M.F., Volt	Color
0	0	0	
2	0.095	0.93	Brown
5	......	1.10	Light blue
7	......	1.10	Light blue
10	0.045	1.20	Green blue
15	......	1.25	Yellow
20	0.040	1.35	Yellow

Rosenheim obtained a similar series of colored oxides in reversed order by the cathodic reduction of H_2WO_4. He started with yellow and ended with brown WO_2. Our results are analogous to his in that we have the same series of colors formed electrolytically, but differ from his results in that we have anodic oxidation and Rosenheim had cathodic reduction.

In the literature we find mention made of many tungsten oxides. Some of these are:

WO	Black[29]
WO_2	Brown[30]
W_2O_5	Blue[31]
W_4O_{11}	Blue[32]
W_5O_{14}	Green Blue[33]
WO_3	Yellow[34]

Mixtures of these oxides produce intermediate colors. Brown and blue give purple; blue and yellow give green. These colors agree with the colors obtained by the anodic oxidation of tungsten.

It is obvious that the degree of passivity depends on the nature of the oxide film which covers the tungsten. The brown oxide is less noble than the blue or the yellow.

When the current density is very low, and the volume of electrolyte is very large, and the diffusion comparatively rapid, no passivity was observed and no colored films were formed until the electrolyte had become saturated with $W(OH)_6$. Passivity in this case is accompanied by a cloudy precipitate. Passivity is a function of the volume of electrolyte used and the rate at which the anode products are dissolved. The solubility of the anode films was shown by allowing a "passified" anode, which had been thoroughly washed with distilled water after electrolysis, to stand in fresh unused portions of the same electrolyte in which it had been made passive for an hour or two. The time depended on the electrolyte.

A sample of "passified" tungsten became "active" by allowing to stand over night in a tightly sealed bottle of freshly distilled water. Solution of NaOH, KOH, NH_4OH, etc., make "passive" tungsten "active" almost instantly. The passivity of tungsten is due to a film of adherent oxide or hydrated oxide, and is a function of the rate R at which the film is produced, and the rate R_1 at which the film is dissolved into the solution used to produce it. If $R = R_1$ we have equilibrium, while if $R > R_1$ the metal becomes passive.

We have found that tungsten dissolves anodically in aqueous solution of NaOH and KOH with the formation of the respective ortho tungstates.

$$W + 6OH = W(OH)_6$$
$$W(OH)_6 + 2NaOH = Na_2WO_4 + 3H_2O$$

Passivity occurs only when the current density is so high that the rate of formation of $W(OH)_6$ is faster than the rate of solution and diffusion in NaOH.

We have found that tungsten dissolves anodically in a solution of HCl (gas) in absolute ethyl alcohol without becoming passive and without the liberation of gas. The anode solution becomes yellow, due to the dissolved WCl_6, and the cathode solution becomes green, due to reduction.[35]

We have found that tungsten dissolves anodically in NH_4OH, NH_2OH, the four methyl ammonium hydroxides, the four ethyl ammonium hydroxides, and propyl ammonium hydroxides within wide limits of current density without becoming passive. The first product of the reaction, W(OH), dissolves on the electrolyte to form salts.

Ekeley[36] has found that $H_2W_2O_4$ dissolves in amines to form salts which are analogous to $(NH_4)_6W_7O_{24}$. As an example:

H_2WO_4 with $C_2H_5NH_3OH$ forms $(C_2H_5NH_3)_6W_7O_{24} \cdot 5H_2O$ His analysis of the salts conforms with his formulæ.

Electrolyzing $C_2H_5NH_3OH$ between tungsten anodes produces $(C_2H_5NH_3)_6W_7O_{24} \cdot 5H_2O$. Analogous salts are obtained with

CH_3NH_3OH; $(CH_3)_2NH_2OH$; $(CH_3)_3NHOH$; $(CH_3)_4NOH$
$(C_2H_5)_2NH_2OH$; $C_2H_5)_3NHOH$; $(C_2H_5)_4NOH$
$(C_3H_7)NH_3OH$; $(C_3H_7)_2NH_2OH$, etc.

In NH_4OH tungsten dissolves anodically with a valence of 6 and 100 per cent efficiency to produce ammonium paratungstate $(NH_4)_6W_7O_{24}$. NH_4Cl was added to increase the conductivity of the solution. In conjunction with this experiment, we determined, from the loss in weight of the anode, the electrochemical equivalent of tungsten and found that when the metal dissolves with a valence of 6 the value of the electrochemical equivalent was 0.3173 mg. per coulomb. The theoretical value calculated from the formula

$$E_w = \frac{\text{At Wt}}{\text{Valence} \times 96580} = \frac{184}{6 \times 96580}$$

is 0.3175 mg. per coulomb[37].

We have found that tungsten also dissolves anodically in NH_2OH. We have not determined the salt formed, but it is probably analogous to ammonium paratungstate.

The anodic behavior of tungsten in aliphatic substitution products of NH_2OH, and the aromatic hydroxyl compounds and substitution products will be discussed in a future paper.

The Use of Tungsten in Cells

Fink[38] mentions the use of tungsten in cells in a paper on "The Applications of Ductile Tungsten," and promises good results both in voltaic and in standard cells. We have since made a further study of these two types of cells and taken up the application of W to storage cells.

VOLTAIC CELLS

If W is to be used as anode in a voltaic cell, it is desirable to use an electrolyte in which both the tungsten and the anodic-reaction products are most soluble. Barring KCN, tungsten is most soluble in solutions of KOH or NaOH. The E.P. W | sol. will be algebraically lowest (or in commoner terms the highest — value) in NaOH solutions[39]. In addition to the anode, it is desirable to have as a cathode, a metal, the E.P. of which is a high + value in the same electrolyte (if possible). Hg and Ag are two such metals.

Mercury has an E.P. in a saturated solution of HgO in 1/1 n. NaOH of +0.445 volt[40] compared to calomen = +0.56, or —0.115 compared to cal. = O, or +0.168 volt compared to H = O. Silver in a saturated solution of Ag_2O in 1/1 n. NaOH has an E.P. of +0.655 volt[41] when cal. = +0.56, or +0.378 when H = O. The E.P. W | NaOH = —0.039 when cal. = +0.56, or —0.316 when H = O.

The emf. of the combinations

Hg | HgO | NaOH || NaOH | W
and Ag | Ag_2O | NaOH || NaOH | W

will then be respectively

$$(+0.445) + -(-0.039) = 0.484 \text{ volt}^{42}$$
$$(+0.655) + -(-0.039) = 0.694 \text{ volt}^{43}$$

The mercury and silver are both positive to the tungsten.

To increase the emf. of the cell it is only necessary to increase the concentration of the NaOH solution.

TABLE XIV

Normality of NaOH	E.M.F. Fused W.	Powdered W.
	Volts	Volts
10	0.595	1.050
5	0.575	1.005
2	0.530	0.920
1	0.484	0.870
0.5	0.440	0.822
0.2	0.381	0.777
0.1	0.343	0.730
0.05	0.315	0.695

The results are very promising with tungsten, both as fused slugs and as metal powder. In our preliminary tests the metal powder has given higher emf. values than the fused metal.

Following are readings taken on a small experimental cell. The voltage was read across the electrodes of the cell. Resistance was put in series with the cell and the ammeter.

Volts	Amps.
1.05	Open
0.95	0.0057
0.90	0.0120
0.80	0.0220
0.60	0.0430
0.40	0.0640
0.20	0.0850
0.10	0.0950
0.05	0.1000
0.01	0.1020

Other cells in which W enters either as metal or compound are being studied.

STANDARD CELLS

In connection with the use of tungsten in standard cells we have made the following observations:

TABLE XV

1 Electrodes	2 E.M.F.	3 E.P. Sol | Metal HgO = +0.445
Sat. $Na_6W_7O_{24}/Hg_6W_7O_{24}/Hg$	−0.401 Volts	−0.846 volts
Sat. $Na_6W_7O_{24}/Cu_3W_7O_{24}/Cu$	−0.235	−0.690
Sat. $Na_6W_7O_{24}/W$	+0.152	−0.297
Sat. $Na_6W_7O_{24}/Zn_3W_7O_{24}/Zn$	+0.302	−0.143
Sat. $Na_6W_7O_{24}/Cd_3W_7O_{24}/Cd$	+0.583	+0.138

Single potential measured with auxiliary electrode Hg | HgO | NaOH = +0.445 volt.

Combining these single electrodes one with another we obtained the combinations which gave the emfs. as shown in Table XVI.

The emf.'s of the combinations check up very well with the theoretical emf.'s calculated from the E.P.'s of the single electrodes, Table XV

These cells are still under investigation and further reports on tests made on their temperature coefficients, life and stability will be given.

TUNGSTEN STORAGE BATTERY

At present we have under investigation several cells made with combinations of tungsten and tungsten oxides.

These cells, A, B, C (Table XVII), were made with tungsten and tungstic acid. The three combinations are shown in the table. Cell A had tungsten and tungstic acid as the positive electrode and tungsten metal

TABLE XVI

+ Hg	$Hg_6W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	− W		= +0.552 volts
+ Cu	$Cu_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	− W		= +0.395
− Zn	$Zn_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	+ W		= +0.154 volts
− Cd	$Cd_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	+ W		= +0.434
+ Hg	$Hg_6W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Cd_3W_7O_{24}$	− Cd	= +0.981 volts
+ Hg	$Hg_6W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Zn_3W_7O_{24}$	Zn	= +0.703
+ Hg	$H_6W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Cu_3W_7O_{24}$	− Cu	= +0.134
+ Cu	$Cu_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Cd_3W_7O_{24}$	− Cd	= +0.831 volts
+ Cu	$Cu_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Zn_3W_7O_{24}$	− Zn	= +0.537
+ Zn	$Zn_3W_7O_{24}$	$Na_6W_7O_{24}$ sat.	$Na_6W_7O_{24}$ sat.	$Cd_3W_7O_{24}$	− Cd	= +0.283

as the negative before charging. Cell B had tungsten and tungstic acid as both electrodes, while cell C had tungsten-tungstic acid as negative electrode and tungsten as positive, being the reverse of A, before charging. The cells were connected in series and charged. The emf. of *each* cell was measured immediately after charging and found to be 3.00 volts for cell A, 3.20 volts for cell B, and 6.20 colts for cell C. Twenty-four hours after charging the cells, the emf.'s had dropped to 0.2 volt, 0.55 volt and 0.85 volt respectively. The cell C having W | WO_2 as positive electrode and W | W_2O_5 as negative electrode has so far been the most satisfactory.

TABLE XVII—BEFORE CHARGING

Type	Positive Electrode	Negative Electrode	E.M.F.
A	W | WO_3. xH_2O	W	+0.08
B	W | WO_3. xH_2O	WO_3. xH_2O | W	0
C	W	WO_3. xH_2O | W	−0.08

TABLE XVIII—AFTER CHARGING

Type	Positive Electrode	Negative Electrode	After Charging, E.M.F.	24 Hours After Charging, E.M.F.
A	W/WO_3. xH_2O	W	Volts +3.00	Volts +0.2
B	W/WO_3. xH_2O	Blue W/W_2O_5. zH_2O	+3.20	+0.55
C	Brown W/WO_2. yH_2O	Blue W/W_2O_5. zH_2O	+6.20	+0.85

The results obtained with tungsten storage cells are very promising and will be discussed more fully in a more detailed paper which will follow.

Summary

1. A brief review of the literature is given.

2. The single potentials of tungsten in n/n solutions of acids, alkalies and neutral salts were calculated from e.m.f. measurements.

From emf. measurements and calculated E.P. we have found that:

3. Tungsten has a lower potential in n/1 alkalies than in n/1 acids and a lower potential in n/1 acids than in n/1 solutions of neutral salts.

4. Tungsten has a lower potential in n/1 KCN solutions than in n/1 solutions of KOH (or NaOH) and a lower potential in the latter than in a n/1 NH_4OH solution. The potential in n/1 KOH or (NaOH) corresponds to that of thallium in a thallium chloride solution containing n/1 Tl ions.

5. Tungsten has a lower potential in n/1 H_2SO_4 than in n/1 HCl, and a lower potential in the latter than in n/1 HNO_3. The potential of W in HNO_3 corresponds to that of Cu in a $CuCl_2$ solution containing n/1 Cu ions.

6. The order of potential of W in n/1 solutions of neutral salts is as follows: KNO_3, KF, KBr, KCl, K_2SO_4, KI, the potential being highest in solutions of KI.

7. It is shown that in solutions of tungsten in acids, tungsten occurs as cation, whereas in alkaline solutions tungsten occurs in the anion.

8. Tungstic acid is more soluble in n/1 H_2SO_4 than in n/1 HCl and more soluble in n/1 HNO_3. Direct chemical tests confirm this.

9. Tungstic acid hydrolyzes and goes into solution as $W(OH)_6$ in n/1 solution of H_2SO_4, HCl, HNO_3. W appears in the cation.

10. $W(OH)_6$ in water is an electrolyte and not a colloid.

11. Tungsten dissolves anodically in aqueous and non-aqueous solutions of alkalies, acids and salts.

12. Tungsten anodes become passive in aqueous and non-aqueous solutions of alkalies, acids and salts.

13. Tungsten becomes passive in aqueous solution of alkalies and organic solutions of alkalies, acids and salts *only* at very high current densities.

14. Tungsten becomes passive in aqueous solutions of acids and salts even at low current densities. It stays active in these solutions only at very low current densities.

15. The passivity of tungsten is due to adherent films of hydrated tungsten oxides. The films may be readily dissolved and the passivity of the metal thereby destroyed.

16. The hydrated oxide films appearing on the anode vary in color from brown, thru blue to yellow. The degree of passivity varies with the color of the film.

17. The passivity phenomena observed can be readily interpreted by the oxide theories of passivity.

18. The electrochemical equivalent of tungsten was found to be .3173 mg. per coulomb. This corresponds very closely with the theoretical.

19. Experiments on the use of tungsten in voltaic, standard and storage cells are recorded. The phenomena observed in connection with the storage cell are of particular interest. The potential difference between brown oxide (positive) and blue oxide (negative) is +0.75 V.

This work was carried out in the research laboratory of the Edison Lamp Works, Harrison, N. J., under the direction of Dr. C. G. Fink.

Harrison, N. J.

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Stability of Paraffin Hydrocarbons

By Gustav Egloff and Robert J. Moore

(Contribution from the Havemeyer Chemical Laboratory, Columbia University No. 291.)

In current opinion there exists a belief in regard to paraffin hydrocarbon stability that has become almost axiomatic, namely, that with increase in the boiling point and greater complexity of the molecule, hydrocarbons are the more readily decomposed, either into their ultimate products or into intermediate compounds. It is the aim of this research to show that such a belief is untenable.

A statement such as the following, "It is well known that the simpler petroleum hydrocarbons are stable *at much higher temperatures* than those of higher molecular weight,"[1] is met with time and again, but no specific references to experiments which verify it can be found. This opinion seems to have originated from the results of simple atmospheric distillation of crude petroleum where cracking has been noted at approximately 200 deg. C. and upward,[2] after the lower-boiling-point paraffins have been distilled off. But the latter have not been subjected to the higher temperatures. If now we take these low-boiling-point paraffin hydrocarbons, and also those boiling at 200 deg. C. and upward, and subject them to a higher temperature, say 700 deg. C., their *true relative stability* could then be determined. This is essentially the scope of the following investigation.

It will be shown experimentally that stability is not a direct function of the complexity of the paraffin chain molecule, but that if stability is graphed against the boiling points of the paraffins there results a curve having the maximum stability at about 250 deg. C. representing the compounds ($C_{12}H_{26}$ to $C_{15}H_{32}$), minima at the lowest boiling points (C_5H_{12} to C_9H_{20}) and the highest boiling points ($C_{19}H_{40}$ to $C_{23}H_{48}$). The above compounds have been isolated from a Pennsylvania paraffin base petroleum oil.[3] Stability will be given in

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terms of per cent, specific gravity and refractive index of the recovered oils, and in the distillation analysis and aromatic formation in the recovered oils, compared with the original fractions, per cent to carbon and gas; and volume of gas formed.

General Procedure

A Pennsylvania paraffin base crude oil was fractionated in cuts to 150 deg. C., 150-200 deg., 200-250 deg., and above 250 deg C. under vacuum into cuts of 50 deg. each. The residue, a semi-solid, was discarded. After the specific gravity, index of refraction, per cents of unsaturated and nitratable hydrocarbons were determined, each fraction was then subjected to a temperature of 700 deg. C. in an electrically heated furnace by passing the oil through at the rate of 200 c.c. per hour. The volume of gas formed was taken and its unsaturation and hydrogen content determined. The recovered oils were measured and analyzed as follows: distillation, specific gravity, refractive index, unsaturateds, and benzene, toluene and xylene content.

Specific gravities were taken with the Westphal balance at 15.5 deg. C., and where amounts were small with a 1 c.c. capacity pycnometer. A Pulfrich refractometer was used for index of refraction values. Unsaturation and nitrative methods of procedure have been previously published.[4]

The distillation was conducted by means of a Glinsky distilling head and the fractions made after several redistillations according to a method previously described.[5] The cut to 95 deg. C. represented the benzene fraction, 95 to 120 deg. C. the toluene fraction, and from 120 to 150 deg. C. the xylene fraction.

Analysis of Starting Oil.

The Pennsylvania petroleum crude oil was distilled by means of a 3 liter Engler distillation flask in two 1800 c.c. portions in fractions up to 150 deg., 150 to 200 deg. C., 200 to 250 deg. C., and in vacuum at 150 deg. to 200 deg. C., and from 200 deg. to 250 deg. C. Distillation in vacuum was carried on, due to cracking taking place at 250 deg. C. and atmospheric pressure. These fractions for simplicity's sake will be called subsequently fractions A, B, C, D, E.

TABLE 1—ANALYSIS PETROLEUM CRUDE OIL

Temperature, Deg. C. of Fractions	Oil A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Per cent by volume	18.8	15.5	13.1	14.3	12.1
Specific gravity	0.724	0.763	0.786	0.811	0.833
Refractive index	1.40156	1.42271	1.43507	1.44773	1.45872
Per cent unsaturated	1.5	2.5	1.0	1.5	0.5
Per cent nitratable hydrocarbons	3.0	7.0	1.5	5.5	4.5

FURNACE USED

The furnace used for the following work was electrically heated over a length of 18 in., and has been described in detail elsewhere:[6]

DETAILS OF THERMOLIZATION

For each run 300 c.c. of the oil were passed at the rate of 200 c.c. per hour in the cracking zone. The temperature of this area was kept constant at 700 deg. C. within + or — 5 deg. C. The temperature was recorded by means of a base-metal thermocouple calibrated against a platinum-iridium standard. The condenser was surrounded with ice and the recovered oil collected in a receiver, while the gas passed through a standard referee wet meter and collected directly into a Hempel burette for analysis. The volume registered on the meter in cubic feet was converted to liters by the factor 28.315. The gas was analyzed for unsaturated hydrocarbons by fuming H_2SO_4, which although it is known to absorb a certain per cent of the higher paraffins[7] was nevertheless sufficiently accurate for this work.

The hydrogen content of the gas was determined by means of Jaeger's fractional combustion method modified by Whitaker and Leslie.[8] A discussion of this method has been made by Burrell and Oberfell[9], and also by Porter and Taylor.[10]

A. The Percentage, Specific Gravity and Refractive Index of the Recovered Oils

TABLE 2

Temperature, Deg. C. of Fractions	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Per cent recovered oil by volume	2.3	29.3	66.7	25.0	20.0
Specific gravity	0.777	0.790	0.794	0.858	0.953
Refraction index	1.43663	1.44076	1.44206	1.46486	1.49428

The stability of the hydrocarbons present in the fractions at 700 deg. C. increased as the boiling points increased, reaching a maximum in the cut 200 to 250 deg. C. and then decreased. The least stable of the hydrocarbons were those boiling to 150 deg. C., which contained mainly the paraffin hydrocarbons pentanes to nonanes.

The percentage yield of the recovered oils from the thermolized fractions indicates quite clearly the gradient of the stability of the starting, mainly paraffin hydrocarbons. The paraffins apparently reached a maximum stability under the conditions of the experiment in the cut of 200 to 250 deg. C., and then decreased in the higher boiling point fractions. This fact is brought out quite forcibly when one takes the values of the percentage of the starting fractions decomposing to form gas and carbon (Table 3).

TABLE 3—THE PERCENTAGE OF STARTING FRACTIONS DECOMPOSED TO FORM CARBON AND GAS

Temperature, Deg. C.	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Per cent to carbon and gas	97.7	70.7	33.3	75.0	80.0

The maximum of 97.7 per cent occurs in the lowest boiling point paraffin hydrocarbon fraction and reaching a minimum of 33.3 per cent in fraction C, while a maximum is also shown in fraction E of 80 per cent. The most stable paraffins are those somewhat midway between the two extreme boiling point paraffin hydrocarbons.

The specific gravity of the recovered oils increases from the lowest to the highest boiling point fraction, although not markedly higher than the values of the starting fractions, except the fraction boiling in vacuum between 200 and 250 deg. C. Table 4 tabulates the two sets of values:

TABLE 4

Temperature, Deg. C. of Fractions	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Sp. gr., original fraction	0.724	0.763	0.786	0.811	0.833
Sp. gr., thermolized fractions	0.777	0.790	0.794	0.858	0.953

In each case the thermolized oil shows a higher specific gravity value, which is to be expected as apparently in all thermal decomposition work of paraffin hydro-

[4]Egloff and Twomey, Met. and Chem. Eng. 14, 247, 1916.
Egloff and Moore, Ibid. 15, 387, 1916.
[5]Rittman, Twomey and Egloff, Met. and Chem. Eng. 14, 70, 1915.
[6]Whitaker & Rittman, J. Ind. Eng. Chem. 6, 472, 1914.

[7]Anderson and Engelder, J. Ind. Eng. Chem. 6, 989, 1914.
Worstall, J. A. C. S. 21, 245, 1899.
Orndorff and Young, Am. Chem. J. 15, 249, 1893.
Burrell and Seibert, Bull. Bureau of Mines, 42, 45, 1913.
[8]Jour. Ind. Eng. Chem. 8, 684, 1916.
[9]Jour. Ind. Eng. Chem. 8, 228, 1916.
[10]Proc. Am. Gas Inst. 9, 255, 1914.
J. Ind. Eng. Chem. 6, 845, 1914.

carbons, aromatic compounds are formed, and these have a higher specific gravity than the paraffins, as shown by averaging those boiling within the limits:

	Average Spec. Gravity Paraffin Hydrocarbons	Spec. Grav. Aromatics
Benzene cut 0° to 95° C.	0.720	0.881
Toluene cut 95° to 120° C.	0.730	0.871
Xylene cut 120° to 150° C.	0.760	0.869

Since the specific gravity of hydrocarbons is an additive property, the physical constant of a thermolized oil would show an increase over the starting paraffin hydrocarbons whenever aromatic compounds were formed.

The specific gravity of the fraction 200 to 250 deg. C. shows the least change in value due to thermolization, which in turn checks up the high per cent of recovery of the starting fraction, and the low per cent decomposing to form carbon and gas.

The refractive index values of the recovered oils increased as the boiling points of the fractions, viz., showing the same tendency as the specific gravity values. A comparison of the refractive index values of the thermolized with the original fractions is shown in Table 5.

TABLE 5

Temperature, Deg. C. of the Fractions	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Refractive index original fractions	1.40156	1.42271	1.43507	1.44773	1.45872
Refractive index thermolized fractions	1.43663	1.44076	1.44206	1.46486	1.49428

The physical constant of refractive index in each case shows a higher value of the fractions after thermolization. Similarly to specific gravity, refractive index is an additive value for hydrocarbons, and will likewise note *percentage* aromatics when present in an oil, due to their higher value when compared to paraffins. A comparison of the refractive indices of paraffin and aromatic hydrocarbons within a similar boiling point range shows the wide difference in the values in the following table:

	Boiling Point Range	Average Refractive Indices
Paraffins	68 to 174° C.	1.403
Aromatics	80.4 to 167° C.	1.501

The least change in the refractive index value of the thermolized oils occurred in the fraction 200-250 deg. C., where the least thermal decomposition took place under the conditions of the experiment.

TABLE 6. DIFFERENCES IN THE SPECIFIC GRAVITIES AND REFRACTIVE INDEX OF THE ORIGINAL AND THE THERMOLIZED FRACTIONS

Temperature, Deg. C	A to 150	B 150-200	C 200-250	D, 150-200, Vacuum	E, 200-250 Vacuum
Spec. Gravity	0.053	0.027	0.008	0.047	0.120
Refraction Index	0.03507	0.01805	0.00699	0.01713	0.03556

The evidence as to the changes taking place in the original fractions after thermolization is nowhere brought out more clearly than by taking the differences in the specific gravity and refractive index values between the starting and the recovered oils. The values for the specific gravity and refractive index show a minima in both cases in the fraction from 200 to 250 deg.

The specific gravity in fraction C shows a difference of 0.008 in the recovered oil and 0.00699 for the refractive index, which indicates a relatively small change in the composition of the recovered oil from the starting fraction. These two sets of values bring out forcibly the greater stability of the paraffin hydrocarbons ($C_{12}H_{26}$ to $C_{15}H_{32}$) under the conditions of the experiment of 700 deg. C. and rate of oil flow of 200 c.c. per hour, than those boiling below and above this fraction.

B. The liters of gas per liter of oil used, the percentage of unsaturateds and hydrogen in the gas

TABLE 7

Temperature, Deg. C. of the fractions	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Liters of gas per liter of oil used	710.2	560.7	420.4	476.7	514.4
Percentage unsaturateds	16.1	39.9	40.0	40.6	42.2
Percentage hydrogen	40.2	24.0	20.5	15.2	13.5

The liters of gas per liter of oil used decreased to a minimum at the fraction 200-250 deg. C. The maxima were found to be at the lowest and highest fractions. The fraction boiling to 150 deg. C. gave 710.2 liters of gas composed of hydrocarbons and hydrogen. This value is in accord with the other data, indicating the low stability of paraffin hydrocarbons boiling to 150 deg. C. in comparison to the higher boiling point fractions. The minimum of 420.4 liters occurred in the fraction 200-250 deg. C., where the least decomposition of the starting oil took place.

The analysis of the gas samples resulting from the thermal decomposition of the fractions gave an increasing percentage yield of the unsaturateds with a rise in the boiling point of the fractions. The percentage yield of unsaturateds increased from 16.1 to 42.2 in the highest fraction. In the last four fractions only a 2.3 per cent difference of the unsaturateds was noted and three of the values are almost identical.

The hydrogen content of the gas decreased rapidly from 40.2 per cent to 13.5. The maximum hydrogen percentage occurred in the fraction boiling to 150 deg. C., while the minimum occurred at the highest boiling point fraction. As the ultimate products of all thermal decomposition of hydrocarbons are hydrogen and carbon, it is significant as indicating the stability of low boiling point hydrocarbons at elevated temperatures,[11] when the percentage yield of the starting 150 deg. C. fraction is 2.3 per cent and the gas analysis 40.2 per cent hydrogen—that in reality they are much less stable at 700 deg. C. than the higher boiling point paraffin hydrocarbons.

C. The distillation analyses of the recovered oils

In the introduction it was stated that one object of this investigation was to show that one of the current hypothesis of paraffin hydrocarbon stability is not tenable, namely, that the higher the boiling point and more complex the molecule, the more readily is it broken up, either into its ultimate products or into intermediate compounds of widely different character. The proof of this untenableness is offered by various experimental results. But of no small value to this end are the distillation figures of the recovered oils, from which some interesting relations may be drawn.

TABLE 8. DISTILLATION ANALYSIS OF RECOVERED OIL

Temperature, Deg. C	A, to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
To 95	7.0	2.4	1.0	8.8	16.6
95-120	18.0	8.9	2.6	2.8	10.0
120-150	35.5	29.4	5.0	2.6	11.1
150-175	15.3	24.8	15.4	4.0	0.5
175-200	..	16.5	8.7	2.6	0.8
200-225	..	10.0	31.5	6.5	2.5
225-250	..	5.2	19.8	20.0	5.2
250-275	..	..	8.3	22.9	5.9

Since our starting oils were mainly pure paraffins whose boiling points ranged from 150 deg. for A to 350 deg. for E, we should expect (if the breaking down of the hydrocarbon is a direct function of the complexity of its molecule) that the distillation fraction to, say, 95 deg. C. of each oil could be expressed graphically in a straight line. That is, that a larger percentage to 95 deg. C. was recovered with increasing boiling point

[11]Egloff, Met. and Chem. Eng., 16, 692, 1916.

of the starting oil. But such is not the case. The distillation figures for the 95 deg. C. cut show a minima for oil C (B.P. 200-250), the percentages being as follows: 7.0, 2.4, 1.0, 8.8, 16.6 from oils A to E. Fraction 95 deg. to 120 deg. C., which shows the largest boiling point distinction from these higher boiling point originals, also shows a minimum for the oil C. Since the five oils were run under exactly similar conditions, there seems to be no doubt but that these parallel tendencied values, high at each end and lowest at oil C, betoken a characteristic of the latter oil to greater stability under heat. The same conclusion will be arrived at subsequently from other considerations.

D. The Specific Gravity of the Distillation Cuts of the Recovered Oil

Table 9

Temperature, Deg. C	A, to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
To 95	0.790	0.800	0.823	0.874	0.859
95-120	0.744	0.790	0.822	0.873	0.875
120-150	0.761	0.770	0.798	0.865	0.879
150-175	0.767	0.773	0.775	0.861	0.860
175-200	0.780	0.791	0.783	0.851	0.850
220-225	0.790	0.803	0.789	0.842	0.858
225-250	0.796	0.810	0.798	0.836	0.954
250-275	..	..	0.811	0.838	0.967

The specific gravity values of the distillation cuts increased in general with increase of the boiling points of the starting fractions in the cuts to 95 deg. C., 95-120 deg. and 120-150 deg. C. In the distillation cuts above 150 deg. C. the minimum specific gravity values are found to be in fraction C, the mid-boiling point starting oil.

E. The Refractive Index of the Distillation Cuts of the Recovered Oils

Table 10

Temperature, Deg. C	A, to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
To 95	1.42645	1.44841	1.46634	1.49245	1.48870
95-120	1.42534	1.44237	1.46298	1.49246	1.49488
120-150	1.42645	1.42927	1.44600	1.49060	1.50875
150-175	1.43985	1.43038	1.43269	1.48825	1.52998
175-200	1.44880	1.44136	1.43401	1.47713	1.53559
200-225	1.44990	1.45041	1.43683	1.47274	1.54886
225-250	..	1.46288	1.44166	1.46912	1.55088
250-275	..	..	1.44791	1.46585	1.56239

The refractive indices follow somewhat the same trend as the specific gravity values, and simply reinforce the evidence provided by the other physical constants used in these experiments.

F. The percent of unsaturated hydrocarbons in the distillation cuts of the recovered oils

Table 11

Temperature, Deg. C	A, to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
To 95°	18.0	9.5	25.0	12.5	17.5
95-120	13.0	10.0	22.0	20.0	25.0
120-150	12.0	5.0	7.5	13.0	20.0
150-175	11.5	5.0	2.5	16.0	23.0
175-200	..	6.0	2.5	9.5	15.0
200-225	..	12.5	5.0	2.5	(Naphthalene present)
225-250	..	19.0	2.0	7.5	..

No specific regularity in the percentage of unsaturated hydrocarbons in the various distillation cuts is to be noted. The bulk of the unsaturated hydrocarbon formation has taken place in the three cuts to 150 deg. C. The maximum formation of unsaturateds occurred in fraction C in cuts to 95 deg. C., 95-120 deg. C., and 120-150 deg. C., indicating that this particular fraction formed the amylenes, hexylenes, and heptylenes to decylenes most readily. Fractions C, D and E formed upon thermolization unsaturated hydrocarbons in much higher percentage yields than the low boiling point fractions A and B. The percentage of unsaturateds in the gas with the exception of fraction A gave only a 2.3 per cent difference in the other four fractions—ranging around 40 per cent in value while fraction A gave 16.1 per cent of unsaturated hydrocarbons. Since the percentage of hydrogen decreased in fraction A from 40.2 to 13.5 in fraction E, and the unsaturateds increased from A to B in the gas, and showed higher values in the distillation cuts in fractions C, D and E in comparison to A and B, with a maximum in the distillation cuts of fraction C, we have two added angles from which to judge the stability of the hydrocarbon fractions started with, that the most stable paraffin hydrocarbons under the conditions of the experiments are those boiling between 200 and 250 deg. C. having formulas from $C_{12}H_{26}$ to $C_{15}H_{32}$.

G. The percentage yield of the aromatics—benzene, toluene and xylene in the recovered oils

Table 12

Temperature, Deg. C. of Fractions	A to 150	B, 150-200	C, 200-250	D, 150-200, Vacuum	E, 200-250, Vacuum
Per cent by volume benzene	3.1	1.2	0.8	8.4	14.4
Toluene	1.3	3.8	1.0	2.8	10.0
Xylene	2.2	2.7	2.0	2.5	11.1

In the recovered oils the yields of benzene ranged from 0.8 to 14.4 per cent. The maximas occurred in the low and high boiling fractions and the minimum in the middle fraction. The toluene percentage ranged between 1.3 and 10, while xylene gave values from 2.2 to 11.1.

The formation of aromatic hydrocarbons is apparently independent of the paraffin hydrocarbons started with. Whether the paraffins are short chained with few isomers or long chained compounds with many isomers, they all apparently decompose, forming the ethylene seried, smaller molecular weight paraffin and aromatic hydrocarbons.[12]

H. The percentage yield of the aromatics—benzene, toluene and xylene on the basis of oil used for production

Table 13

Temperature, Deg. C. of fractions	A to 150	B, 150-200	C, 200-250	D, 145-200, Vacuum	E, 200-250, Vacuum
Per cent by volume benzene	0.07	0.4	0.6	2.1	2.9
Toluene	0.02	1.1	1.1	0.7	2.0
Xylene	0.05	0.8	1.3	0.6	2.2

The percentage yields of the aromatic hydrocarbons, benzene, toluene and xylene, on the basis of oil used, emphasizes again the importance of the starting hydrocarbon oil in their production. There is, as illustrated by the above table, an increase from 0.07 to 2.9 per cent in the benzene yield, toluene varies between 0.02 and 2 per cent, and xylene between 0.05 to 2.2 per cent. These values are widely different and show that groups of the high boiling point paraffin hydrocarbons in the distillation cuts lend themselves more readily to aromatic formation than the low boiling point paraffins. This is directly in accord with theoretical considerations when one considers the long chain alphatic hydrocarbons, with their many isomers, splitting up into a greater number of the ethylene seried hydrocarbons and lower boiling point paraffins.[13] The ethylene seried hydrocarbons polymerize, readily forming naphthenes, which decompose to aromatic hydrocarbons.[14]

[12] Egloff, Met. and Chem. Eng., 16, 692, 1916.

[13] Haber, Jour. Gasbel., 39 (1896), 377, 395, 435, 452, 799, 813, 830.

[14] De Montmollin, Bull. Soc. Chim., 19, 242 (1916).

General Discussion

Hartogh[15] has reported that by refluxing a sulphuric acid washed benzine having a distillation value of 91 per cent boiling below 105 deg. C. and a specific gravity of 0.698, that after several hours the analysis gave a much wider distillation range, and upon sulphuric acid treatment a 10 *per cent of unsaturated hydrocarbon test*.

Engler and Höfer[16] state that this experiment is open to further verification, for they bring out the points as to how far the oxygen of the air or the catalytic effect of the copper vessel used in the distillation entered into giving the recorded results. Further doubt is thrown upon Hartogh's result by the work of later experimenters, who worked with a heavier Russian benzine of a specific gravity of 0.745 and 98 per cent boiling below 148 deg. C. in one case, and in the other a specific gravity of 0.732 and 95 per cent boiling to 130 deg. C. In both cases no appreciable decomposition of the starting oils was noted.

The criticism of Engler and Höfer is of interest, but even though the air or copper catalysed the reaction so as to give the results recorded by Hartogh of 10 *per cent unsaturation* after distillation, the results are highly significant. Although the decomposition took place by possible catalysers, the results are important when compared with those of the present communication.

It is certain that the viewpoint of the stability of paraffin hydrocarbons toward heat, decreasing with increasing molecular complexity, is no longer tenable from the experimental evidence presented. It is recognized that the behavior of the gaseous paraffin methane in comparison to the liquid paraffins shows marked stability toward heat. In particular methane persists longest in thermal decomposition of hydrocarbons, and is also the most stable of the paraffin hydrocarbons recorded in the literature.[17]

A study of the thermal decomposition of individual paraffin hydrocarbons under like conditions would show methane in all likelihood the most stable, with a decrease in stability as the molecular weight increased, to a minimum, and then a maximum would again be reached in one of the paraffins in the group boiling between 200 deg. and 250 deg. C., $C_{12}H_{26}$ to $C_{15}H_{32}$, with another minimum as the complexity of the molecule increased, and perhaps another maximum in a compound like $C_{60}H_{122}$, with the highest molecular weight paraffin hydrocarbon going to the ultimate products carbon and gas.

As to the theoretical considerations involved in the greater stability of the group of paraffins $C_{12}H_{26}$ to $C_{15}H_{32}$ in comparison to the relatively shorter chained compounds C_5H_{12} to C_9H_{20} information is lacking as to the heats of combustion, heats of formation, internal pressures and similar constants of the higher paraffin hydrocarbons, which would throw light upon the stability of paraffin hydrocarbons.

Conclusions

1. Five fractions of a paraffin-base petroleum oil with boiling points to 150 deg. C., 150-200 deg. C., 200-250 deg. C., and vacuum distilled from 150-200 deg. C. and 200-250 deg. C., have been thermolized at a temperature of 700 deg. C. with a view toward determining their stability at this temperature.

2. It has been established that the fraction boiling between 200-250 deg. C. paraffins with molecular weights between $C_{12}H_{26}$ and $C_{15}H_{32}$ is most stable under the conditions of the experiment.

3. The percentage of starting fraction recovered; to carbon and gas, differences in the specific gravity and refractive indices, volume of gas, per cent of benzene, toluene and xylene in the recovered oil, experimentally determined that the fraction with boiling point between 200-250 deg. C. are the most stable paraffins at 700 deg. C.

TABULATED EXPERIMENTAL RESULTS

	A	B	C	D	E
Distillation temperature of fractions	to 150°C	150-200	200-250	150-200 Vacuum	200-250 Vacuum
Per cent of recovered oil	2.3	29.3	66.7	25.0	20.0
Per cent to carbon and gas	97.7	70.7	33.3	75.0	80.0
Differences in specific gravity of original and thermolized fractions....	0.053	0.027	0.008	0.047	0.120
Differences in refractive indices of original and thermolized fractions..	0.03507	0.01805	0.00699	0.0173	0.03556
Liters of gas per liter of oil used...	710.2	560.7	420.4	476.7	514.4
Per cent of benzene in recovered oil...	3.1	1.2	0.8	8.4	14.4
Per cent toluene...	1.3	3.8	1.0	2.8	10.0
Per cent xylene....	2.2	2.7	2.0	2.5	11.1

4. It has been shown experimentally that the general belief, as exemplified by the statement, "It is well known that the simpler petroleum hydrocarbons are stable at *much higher temperatures* than those of higher molecular weight," is no longer tenable.

Department of Chemistry,
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[15]Dissertation, Bonn. 1908. Also Das Erdöl, 495, vol. 1.

[16]Das Erdöl, 496, vol. 1.

[17]Mayer and Altmayer, Berichte, 40, 2134, 1907; Bone and Coward, Jour. Chem. Soc., 93, 1975, 1908; Ibid, 97, 1219, 1910. Bone and Jordan, loc. cit., 71, 41, 1897. Berthelot, Ann. Chim. Phys., 6, 183, 1905. Pring and Hutton, Jour. Chem. Soc., 89, 1591, 1906. Pring and Fairlie, Report 8th Int. Cong., 21, 65. Holgate, J. Gas Lighting, 106, 25, 84, 1909. Simmersbach, Stahl u. Eisen. 33, 239, 1913. Hollings and Cobb, Gas World, 60, 879, 1914. Whitaker and Alexander, Jour. Ind. Eng. Chem., 7, 484, 1915; Lewes, Jour. Chem. Soc., 61, 322, 1892; Proc. Roy. Soc., 55, 90, 1894; Ibid, 57, 394, 1895. Bone and Coward, Jour. Chem. Soc., 93, 1197, 1908.

Synopsis of Recent Metallurgical and Chemical Literature

Iron and Steel

Influence of the Time of Heating Before Quenching on that Operation.—ALBERT PORTEVIN, in an illustrated article of 52 pages, discusses the above mentioned subject in the January-February number of the Revue de Métallurgie, pp. 9 to 63. In the introduction to his paper, Portevin discusses in a general way, the state of cooling, the state of quenching, heating, the duration of constant temperature, the law of cooling and the interpretation of the results obtained. In the latter he states, that from the theoretical point of view, the effect on the electrical resistance must be considered, as, according to Benedicks, it is a means for quantitatively determining the elements in solid solution. Furthermore, from the practical point of view, most of the interest is based on the effects of heating on the mechanical properties of the material treated; and finally, that for all methods of investigation the micrographical study is of paramount importance.

Chapter I treats of the preliminary study of heating in fused salts. The subject is first covered in a general way, then methods for procedure are described, the latter comprising thermometric and calorimetric methods, and finally a study of the various fused salts used is given. The salts tested were potassium nitrate and nitrite, sodium chloride, potassium chloride, fused calcium chloride, hydrated barium chloride, hydrated strontium chloride and pure potassium chloride. The results obtained under varying temperature conditions

are illustrated by numerous curves. Full explanations accompany the curves.

From here on the subject is divided into two parts: First, the effect of the treatment on the mechanical properties and on the electrical resistance of the ordinary carbon steels, and second, the effect of the treatment on special steels. Under the latter head fall tests made on various samples of chromium, tungsten and molybdenum steels. All results, at every instant, are summarized either in tables or curves, or both. Analysis of samples tested are given, and many micro-photographs illustrate the various effects on the structure of the materials tested.

The conclusions drawn from the work are as follows: First, from the practical point of view the rate of transformation in steels is appreciable even at ordinary temperature, and increases with the temperature, and secondly, from the industrial point of view, the properties of a steel depend essentially on the length of time of heating before quenching. These results were obtained after jointly considering the changes in the mechanical properties, changes in electrical resistance, and the change of structure as examined by the microscope.

In an appendix to the same paper the author elaborates on the laws of heating, the calorimetric determination of the total duration of heating of small samples in an industrial gas furnace, the decarbonization of steels in salt baths, and the thermal determination of the intensity of quenching of steels. Like the main article, the appendix is illustrated by curves, tables and micro-photographs.

Copper

The Metallography of Copper.—Under the title, The Study of Metallography, Internationale Zeitschrift für Metallographie, VII., 124, 1915, M. V. Schwarz treats the metallography of copper. The article is elaborately illustrated and the conclusions drawn by the author are of more than common interest.

Especially of interest are the conclusions drawn on the formation of crystals of copper in the process of electrolysis. The most favorable conditions for the formation of crystals in this process are a low temperature and no agitation of the electrolyte. The cause of the formation of elongated crystals is a lack of diffusion. The disposition of the various crystalline grains may be recognized by the position of the lamellae. The author draws attention to the importance of corrosion figures in the microscopic examination of metals. In a microscopic slide the eyectrolytic crystals appear more brilliant than the surface of the cut which corresponds most exactly with one of the faces of the crystal.

The author claims to have observed the growth of these electrolytic crystals. He discards the idea of the influence of the grain size on the growth of the crystals, but ascribes the form of the crystal obtained to the aging process. This effect disappears on reheating. The "state of youth" of the crystal, as the author terms it, may be explained by aid of the kinetic theory and the law of mass action.

The elongated crystals form normally on the surface of separation. If, therefore, a copper wire is used as cathode, the crystals appear radially. A cut parallel to the surface of the electrode will then clearly show the copper crystallites. If the conditions of electrolysis are changed during operations, the crystals appear in layers. These layers are successive, but the orientation of the crystals remains unchanged. The electrolytic copper crystals are very susceptible to pressure, so on cutting a sample with a very thin saw one observes before reheating the formation of isolated grains which do not melt in the mass.

Another factor of importance is that the author does not approve of the amorphous theory, as an explanation of what occurs between adjacent crystals. The material between the crystals, according to Schwarz, is made up of crystalline copper, so finely crystallized that the individuals cannot be recognized. This mass he calls "cryptocristallines." This mass is less stable towards chemical and heat action, than the actual crystals. The polished surface of a sample is explained as the sliding of an upper surface following the sliding surface of the mass proper. The surface on examination shows no tendency whatsoever of forming amorphous material.

Melting Aluminum Chips.—The Bureau of Mines has undertaken an investigation of this subject and published the results in Bulletin 108. The authors are H. W. Gillett and G. M. James. The bulletin gives an account of experiments made to compare the recovery of metallic aluminium in melting down chips such as are obtained in the automobile factories in machining aluminium castings. As aluminium has sold at three times its normal price for the past year, and as a recovery of but 60 per cent of the metal in the chips is common, and a 90 per cent recovery is commercially possible, the preventable loss is of considerable magnitude. The bulletin discusses the causes of the high loss in the usual method of melting chips, and shows that the difficulty of getting the tiny globules of molten metal resulting from the fusion of the very fine chips, to coalesce, when covered with a skin of oxide and dirt, is apparently the main cause for low recoveries.

Two methods of melting can be successfully used to promote coalescence. In one method the chips are kept just above the fusion point and the globules made to coalesce by hand puddling, which breaks through the skin and makes the globules unite. In this method melting is best done in an iron pot heated by oil.

The other is by the use of a flux which dissolves off the skin of dirt and oxide, producing clean globules which can unite. The flux suggested is 85 per cent common salt, 15 per cent fluorspar, used in large amount (20 to 30 per cent of the weight of the chips) and mixed with the chips before charging. Much higher temperatures are required by this method than by the puddling method, so the iron pot furnace is not practicable and melting is best done in graphite crucibles or in a reverberatory furnace. The flux method does not require the constant hand puddling of the other.

Since the presence of dirt and oxide causes low recoveries, the necessity for care and cleanliness in the collection and storage of chips is emphasized. Chips wet with cutting compound will oxidize superficially on storage, but by drying the chips by centrifuging this can be prevented. Perfectly clean chips can be melted without much loss by either method, while very dirty chips cannot be handled by any method so as to give the high recoveries of clean chips, although the two methods mentioned gave better results on dirty chips than any other methods tried. Care and cleanliness in the collection of chips in the machine shop producing them will give chips from which a high percentage of metal can be recovered, with a corresponding increase in the value of the chips sold by the shop. As on an average 15 per cent of the weight of aluminium castings for automobiles is machined off as chips, the possible saving to the automobile manufacturer is much greater than the cost of replacing careful methods for sloppy methods in the collection of chips.

New Paper Process.—According to the Journal of the London Chamber of Commerce, a process for making paper pulp for newsprint out of Kaing grass, which grows wild in Burma, is a success and steps have been taken toward its manufacture.

Recent Chemical and Metallurgical Patents

Various Electric Furnaces

Electric Melting Furnace.—A revolving arc furnace to be used for melting alloys containing zinc, such as the various brasses, and German silver, or containing manganese, such as ferro-manganese, is patented by HORACE W. GILLETT and JAMES M. LOHR, of Ithaca, N. Y. The furnace is also adapted to the melting and refining of steel. It is of the indirect arc type, the arc being maintained between the electrodes over the charge (the electrodes being horizontal), but no arc is maintained between the electrodes and the charge. In melting yellow brasses agitation has been found to reduce vaporization losses of zinc on pouring, and agitation is provided for in this furnace by rotation of the furnace. The electrodes revolve with the body of the furnace. (1,201,224-5, Oct. 10, 1916.)

Electric Arc Furnace.—An electric furnace in which it is possible to use either freely burning arcs, that is, arcs burning between the electrodes, or arcs burning between the electrodes and the furnace charge, is patented by CLAS W. HARRY VON ECKERMANN of Ljusne and IVAR RENNERFELT of Djursholm, Sweden. Freely burning arcs are stated to be an advantage when melting scrap and the like, in case the charge is nonconductive when cold, and when the chemical reaction in the charge causes a violent boiling and formation of slag, as when puddling pig iron. Arcs contacting with the charge may be of advantage for deoxidizing and desulphurizing when the charge has become melted and the boiling ceased.

By a suitable arrangement of electrodes and connecting cable swith a double-throw switch it is possible, according to this patent, to have the arcs burning either between the electrodes only or between the electrodes and the charge. The idea is illustrated in Fig. 1, which

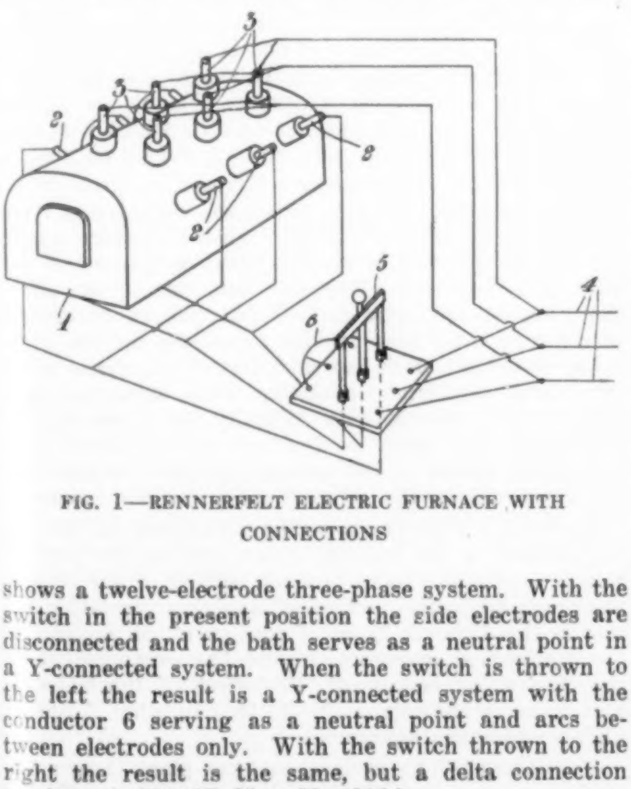


FIG. 1—RENNERFELT ELECTRIC FURNACE WITH CONNECTIONS

shows a twelve-electrode three-phase system. With the switch in the present position the side electrodes are disconnected and the bath serves as a neutral point in a Y-connected system. When the switch is thrown to the left the result is a Y-connected system with the conductor 6 serving as a neutral point and arcs between electrodes only. With the switch thrown to the right the result is the same, but a delta connection results. (1,206,057, Nov. 28, 1916.)

Electric Furnace for Treating Gases.—An electric furnace having a rotating flame for treating gases is patented by IGNACY MOSCICKI of Lemberg, Austria-Hungary. In electric furnaces in which the flame produced by an alternating current rotates under the influence of a magnetic field the reignition of the flame at the instant of reversal is troublesome and requires a relatively higher voltage. The present design attempts to overcome this difficulty by a specially designed conical shape electrode. The chief claim is:

"An electric furnace for the treatment of gases and vapors, in which furnace a high-tension, alternating-current flame rotates under the influence of a magnetic field of force, said furnace having an outer electrode within which is inclosed the reaction chamber; an inner electrode that projects thereinto; a hollow ring which is detachably fastened to the outer electrode so as to be readily exchangeable and is provided with an ignition-edge inclined toward the inner electrode and is arranged for the passage of a cooling medium; the interval between said electrodes measured in the direction of flow of the gases increasing very rapidly; the inner electrode being arranged free to be shifted and to be adjusted relatively to the outer electrode in such manner that the ignition-ring remaining free between the electrodes can be adjusted exactly to the tension of the working current so as to be able first to generate the flame at said ring at every current reversal and then, under the influence of the powerful magnetic field and the great velocity of the gases, to draw the flame out to a great length and absolutely within a small fraction of the period of a single alternation." (1,201,-607, Oct. 17, 1916.)

Induction Furnace.—An induction furnace for the melting of metals is patented by JAMES R. WYATT of Philadelphia, Pa., and assigned to the Ajax Metal Company, Inc., of Philadelphia, Pa. Stirring of the molten charge is accomplished by the motor effect of induced currents flowing in opposite direction close together and at an acute angle to each other. For details of the furnace the patent specification should be referred to. (1,201,671, Oct. 17, 1916.)

Nitric Acid

Nitrogen Fixation Furnace.—A new design of electric furnace for nitrogen fixation is patented by ERNEST K. SCOTT of Belvedere, England (assigned to Atmospheric Nitrates, Ltd., of Manchester, England). "The primary object of the invention is to increase the efficiency of such furnaces by insuring that practically all the air which enters the furnace passes through the arc. This object is attained according to this invention by the employment of electrodes so shaped and disposed that they inclose a central space, which is preferably in the form of an inverted cone, arcing gaps being provided between adjacent electrodes." (1,203,-276, Oct. 31, 1916.)

Improvements in Birkeland-Eyde Furnace.—A method of bracing the electrodes in an electric arc furnace of the Birkeland-Eyde type is patented by CARL O. A. DÖVLE of Notodden, Norway. In the operation of electric arc furnaces with arcs moving along the electrodes, irregularities have occurred due to vibration. In the present patent these vibrations are eliminated by braces. (1,204,349, Nov. 7, 1916.)

Chemical Engineering

Separation of Oils.—Machine shops and garages accumulate from time to time certain quantities of waste oils and greases which have no commercial value, being mixtures of lubricating oils, burning oils, and gasoline. Mr. SIDNEY CORNELL proposes to separate the gasoline and more volatile oils from the heavier lubricating oils, greases, etc., by the following method: A closed retort is provided with two steam coils in the upper and lower part of the retort respectively so that

the upper and lower parts may be heated independently to desired temperatures. The oil mixture is fed into the retort so as to fill its lower half and is heated by means of the lower steam coil while at the same time saturated steam is blown into the oil mixture from below through a number of jet openings in the bottom of the retort. The steam passing through the oil mixture brings it into an emulsified or frothy condition. When the emulsion or froth comes in contact with the upper steam-heated coil above the liquid, separation of the gasoline, benzine, etc., from the emulsion takes place and these light volatile hydrocarbons, together with the remaining steam, distil over into a condenser, where they are condensed. The heavier lubricating oil remains back as residue in the bottom of the retort. (1,202,969, Oct. 31, 1916). [The process has been in operation in a large-scale experimental plant for some time in Long Island City, where we recently witnessed a successful test on separating gasoline from crude oil. As operated, it appeared that cracking plays a part in the process. It is stated that the process, the patent rights of which have been assigned to Mr. Richard Elkins, will be used in a plant in the Oklahoma oil field by the Intercoast Oil & Refining Company.—Editor.]

Aging Wine.—Dr. Arthur Lachman of San Francisco, well known by his charming little book on "The Spirit of Organic Chemistry," and equally well known by his more recent successful business activity in wine making, has patented a process for aging wine in which the wine is subjected to heat, pressure, and electric treatment; to save fuel and to make the operation continuous, the heat of the wine whose treatment has been completed is used to warm up the wine which is to be treated. A pressure of 5 to 25 lb. per square inch is satisfactory for sweet wines, with a temperature of 140 deg. Fahr. The electrical treatment consists of the passage of high-tension alternating current between electrodes in the treatment tank. The process produces in twenty-four hours aging results which otherwise require many months. (1,204,669, Nov. 14, 1916.)

Progress in the Use of Kieselguhr in the Insulation of Metallurgical Equipment

We have repeatedly referred in these columns to the very interesting and progressive work of the Kieselguhr Company of America, with principal offices in Los Angeles and New York, and with mines in Santa Barbara County, Cal., in adapting their kieselguhr products, "celite" and "silocel," to the solution of insulating problems for metallurgical equipment. Progress has especially been made in increasing thermal efficiency and producing greater uniformity of temperature, resulting in an increase of works' capacity and of uniformity of grade of product, together with better working conditions.

Hot-Metal Cars.—Recently, silocel insulating brick have been used for the insulation of hot-metal cars and metal mixers, giving a greater radius for these cars and an appreciably reduced loss through the formation of sculls, and almost entirely eliminating the chilling effect due to heat losses while in the car.

A 2-in. layer of silocel insulation as a backing for the refractory lining reduces the external temperature of the car to such an extent that the hand can be held on the outer shell with entire comfort.

Mains and Bustle Pipes.—The effect of insulating high-temperature mains, flues, and bustle pipes is primarily to give a greater capacity to the stove equipment and produce a more uniform blast temperature at the tuyeres. In one of the several installations in which a 4½-in. course of silocel insulating brick are used as a backing for the lining of bustle pipes the variation in temperature on the far side of the bustle pipe was reduced by more than 50 deg., with a notable increase in the uniformity of the pig produced.

In the operation of waste-heat boilers the flue insulation is of vital importance.

Hot-Blast Stoves.—One of the most serious heat losses occurring in blast-furnace equipment is that through the sides and tops of hot-blast stoves. This effect, of course, is particularly noticeable in the cold weather, which, in certain cases, causes a complete shutdown of the stack, due to inability to obtain the proper blast temperature at the tuyeres. Within the past two years more than sixty hot-blast stoves have been completely insulated in sides and top with silocel products, many of which are now operating under unusually high thermal efficiency.

Crucible Furnaces.—One of the primary considerations in the operating of crucible furnaces is the difficulty in handling high temperatures encountered in this work. In the insulation, for instance, of the back of a crucible furnace with 2½ or 4 in. of insulation, a comfortable working condition is produced for the men, and at the same time it gives an appreciably more uniform furnace than can be obtained in any other manner. A number of crucible-steel furnaces have been insulated with both silocel insulating brick and powder, and are operating under unusually successful conditions.

This same factor, of course, applies to handling case-hardening and tempering furnaces, the majority of which are being insulated with silocel products.

Regenerators.—The insulation of regenerator and checkerwork settings for open-hearth furnaces, and other forms of equipment requiring pre-heated gases, produces increased thermal capacity and a higher average blast temperature, because of the elimination of the valleys and the peaks necessary to take care of the conduction losses in uninsulated equipment. In other words, the working temperature of the blast as it leaves the regenerator is more nearly a straight line in the case of insulated equipment than is possible in the ordinary form of regenerator, in which the heat losses by conduction are allowed to go on unchecked.

Insulation of Foundations.—Heretofore, little or no attempt has been made to check the heat losses from the bases and foundations of high-temperature equipment, although this has been found to be one of the most serious losses. This has been due to the effect that insulating materials of the proper structural strength have not been generally available for this character of work. With the introduction of silocel products, with very high insulating value combined with mechanical strength, this difficulty has been largely overcome, and many of the largest installations of heated equipment in the country are now having their bases, as well as the exposed parts entirely insulated.

By-product Coke Ovens.—The uniformity of interior temperature is of primary importance in the production of coke, either in by-product, beehive or gas generators, and, while the method of applying insulation varies in the different types of equipment, on account of the mechanical construction and the arrangement of the condensing equipment, the effect of insulation is to a large extent comparable to that in other forms of high-temperature equipment.

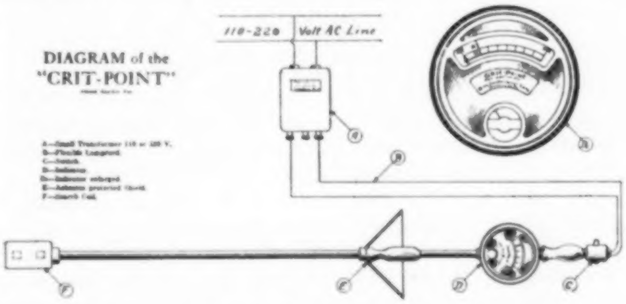
Gas Plants.—The modern coal-gas plant is now entirely insulated from the base to the top, especially the retorts, to give a higher yield of gas, more uniform operating temperatures, and a more uniform grade of coke than has been posible in the older types of equipment. Several of the largest plants in the country are

now completely insulated with silocel products and are producing at an unusually high thermal efficiency.

Oil Stills.—The application of insulation to the settings and mains in oil stills is rather recent, and the effect is very pronounced in the saving of fuel, etc.

The Critical Point in the Heat Treatment of Steel

In the heat treatment of steel it is all-important to know exactly when the critical temperature or the "critical point" is reached. In the "crit-point," a new instrument of the Gibb Instrument Company of Pittsburgh, Pa., use is made of the well-known fact that steel in the process of heating loses its magnetic properties when it is brought to its critical point. Through the medium of electromagnetic coils the magnetic condition of the steel in the furnace is determined. A magnetic indicator is placed in the circuit, so that



this meter immediately indicates whether the steel has reached its critical point. When the surface of the steel in time becomes non-magnetic, or in other words, the temperature of the surface comes up to the critical point, the meter needle approaches the red line indicative of the critical point and gradually comes nearer and nearer to it, as the heat penetrates the steel and the interior is brought to the critical point.

It will be seen that the "crit-point" does not measure temperature. But the exact knowledge of the temperature is irrelevant as long as the heat-treating man has a simple and exact means off hand for ascertaining when the critical temperature is reached.

Tests on a Die-Casting Copper Alloy

The following tests were made on samples of "Ampco" bronze, a 90 per cent copper-base alloy made by the American Metal Products Company of Milwaukee, Wis.

The name bronze is somewhat of a misnomer, as the alloy contains no zinc, tin, lead or phosphorus. It was developed to furnish a low-melting-point copper-base alloy for die casting which should have great strength. It is furnished in grades having a tensile strength of from 50,000 to 100,000 lb. per square inch elastic limit, 20,000 to 45,000, elongation 50 per cent to 4 per cent, reduction of area 28 per cent to 8 per cent and Brinell hardness 70 to 280.

TENSILE TEST OF THE MILWAUKEE ELECTRIC RAILWAY & LIGHT COMPANY

MATERIAL "AMPCO" BRONZE NO. 11 A.C.

Received from the American Metal Products Company

Diameter	0.560
Area	.246
Elastic limit	6,700
Elastic limit, square inches	27,230
Ultimate strength	16,210
Ultimate strength, square inches	65,890
Elongation, inches	25/32
Elongation, 2 in., per cent	39.1
Reduced diameter	.450
Reduced area	.159
Reduced area, per cent	35.4
Fracture	Irregular
Grain	Silky

TENSILE TEST OF ALLIS-CHALMERS MANUFACTURING COMPANY

MATERIAL "AMPCO" BRONZE NO. 11½

Original dimensions	0.505
Original area in square inches	2
Dimensions after fracture	.44
Area after fracture, square inches	1,520
Elastic limit, pounds actual	7,290
Maximum load, pounds actual	16,900
Elongation in inches	49
Elastic limit per square inch	36,450
Tensile strength per square inch	84,500
Per cent elongation in inches	24.5
Per cent reduction of area	24.0

SOLUBILITY TESTS ON "AMPCO" BRONZE NO. 16

MADE BY ELYRIA ENAMELED PRODUCTS CO.

Loss—Grams Cu. Cm.

Solution		Loss, Per Cent	24 Hrs. Cold	4 Hrs. Hot	Loss, Per Cent
Sulphuric acid	10%	.0001	.0001	.0002	.0002
Sulphuric acid	50%	.0001	.0001	.0004	.0004
Acetic acid	5%	.0002	.0002	....	....
Acetic acid	10%	....	....	.0001	.0001
Citric acid	5%	.0001	.0001	....	....
Citric acid	10%	.0002	.0002	.0002	.0002
Formic acid	10%	.0001	.0001	.0001	.0001
Phosphoric acid	10%	.0001	.0001	....	....
Sodium hydroxide	5%	.0001	.0001	....	....
Sodium hydroxide	...	....	....	.0000x	.0000x
Phenol	Con.	.0000x	.0000x	....	....
Lactic acid	10%	.0010	.0010	.0010	.0010
Tartaric acid	10%	.0021	.0021	.0021	.0021
Ammonium hydroxide	Con.	.0006	.0006	....	....
Ammonium hydroxide	28%	.0002	.0002	....	....

SULPHURIC ACID TEST MADE BY HAMMERMILL PAPER CO.

Weights					
Before Test, Grams	After Test, Grams	Loss in Weight, Grams	Loss, Per Cent	Changes of Acid	Time Immersed, Days
27.7158	27.6916	.0242	0.09	20	32
26.4110	26.3917	.0193	0.07	13	30

New York Meeting of American Institute of Chemical Engineers

The winter meeting of the American Institute of Chemical Engineers will be held in New York City from Wednesday to Saturday, Jan. 10 to 13, 1917. All the business meetings and technical sessions will be held at the Chemists' Club. Excursions (for members only) have been arranged for the afternoon of Wednesday, the whole of Thursday, and the afternoon of Friday. A subscription dinner will be held on Thursday.

The following papers will be presented:

Wednesday, **11 a. m.:**

"Unpreparedness," President George D. Rosengarten.

"Recent Developments in Chemical Engineering Equipment," H. D. Miles, president Buffalo Foundry & Machine Company.

"Corrosion of Ingot Iron, Containing Cobalt, Nickel, or Copper," Prof. Herbert T. Kalmus and K. B. Blake, Queens University.

Wednesday, **8 p. m.:**

"The Human Side of the Development of Chemical Industries," G. W. Thompson, National Lead Co.

"The Fixation of Nitrogen," Prof. John E. Bucher, Brown University.

Friday, **10 a. m.:**

"The Decatur Sewage Disposal Plant of the Electrolytic Sanitation Company," William Hoskins, Mariner & Hoskins.

"The Effect of Centrifugal Force on Colloidal Solutions," E. E. Ayres, Jr., Sharples Specialty Co.

"Recent Developments in the Absorption and Distillation of Volatile Liquids," Charles L. Campbell, E. B. Badger & Sons Company.

Friday, **8 p. m.:**

"Chemical Engineering Aspects of Renovating a Sulphide Mill," Hugh K. Moore, Berlin Mills Company.

"Recovery of Benzol from Coke Oven and Illuminating Gas," C. J. Ramsburg, H. Koppers Company

Personal

Dr. **William Beckers** of the Beckers Aniline and Chemical Co., Brooklyn, N. Y., addressed the American Association of Woolen and Worsted Manufacturers at its recent eleventh annual meeting in New York. The title of his paper was "Dyestuffs Progress in America and What Is to Be Expected in the Future; the Relation of the Manufacturer of Explosives to the Manufacture of Dyestuffs."

Mr. **George A. Burrell,** consulting chemist, Pittsburgh, Pa., lectured before the Franklin Institute of Philadelphia, Pa., on December 7th, on the technology of the natural gas gasoline industry.

Mr. **Meyer Davis,** formerly chief engineer, has been appointed manager of the San Francisco office of the Asbestos Protected Metal Company. The office is in the Hobart Building.

Mr. **J. V. N. Dorr** was presented with the John Scott Legacy Medal by the city of Philadelphia on the recommendation of the Franklin Institute, for his inventions along the line of metallurgical apparatus.

Dr. **Sam Eyde, the** well known joint inventor with Prof. Birkeland, of the nitrogen fixation process which is now operating successfully in Norway, passed the half century mark recently. The Scandinavian papers have given a summary of Dr. Eyde's accomplishments, and foremost of these is his active and successful work developing the nitrogen fixation industry in Norway. Three hundred thousand horsepower are operating at Rjukan on this industry alone and the net income of the company, of which Mr. Eyde is manager, was in the year of 1913, 25,000,000 kroner, or close to $9,000,000. At the present time the daily production of this plant is five hundred tons of nitrates. Mr. Eyde made several large donations for various scientific and humanitarian purposes in commemoration of his anniversary.

Mr. **Edwin Higgins** has been elected as consulting engineer of the United States Bureau of Mines.

Mr. **Theodore J. Hoover** has opened an office in San Francisco in the Mills' building.

Mr. **J. E. Johnson,** Jr., consulting engineer of New York City, sailed on December 15 for China on professional business.

Mr. **Frederick Laist** is the new manager of the Washoe Reduction Works at Anaconda, Montana, in which capacity he succeeds **E. P. Mathewson. C. A. Lemmer** has been appointed assistant manager.

Mr. **G. A. Marsh,** superintendent of the Pueblo smelter of the A. S. & R. Co., was in Denver recently, on business.

Mr. **Wm. Motherwell,** flotation engineer, has returned to Nelson, B. C., and has entered consulting practice. Mr. Motherwell's experience began ten years ago at Broken Hill, Australia, and since that time he has had experience in Queensland, Arizona, Colorado and Mexico.

Professor **W. A. Noyes,** director of the chemical laboratory of the University of Illinois, will lecture on "the electron theory" before the Franklin Institute as part of the 1916-1917 program.

Mr. **Raymond B. Price,** vice-president of the United States Rubber Company recently returned to New York from a three months' trip to Europe. He was entertained at luncheon at the Technology Club on December 15, after which he gave a very interesting talk on recent developments in Europe as affecting American business now and after the war. He said that production has been speeded up enormously on all sides in Europe, and the lessons they have learned in efficiency in centralized control and in the relations between labor and capital are not going to be lost after the war but will be retained and utilized in industry.

Mr. **A. K. Richards** is now engineer and superintendent of construction of the Colorado Portland Cement Co. He was formerly with the American Vanadium Co., Mackintosh-Hemphill & Co., of Pittsburgh, and the Cambria Steel Co., Johnstown, Pa.

Mr. **Charles H. Rosenthal,** formerly with the Calco Chemical Company of Philadelphia is now chemist with the Benzol Products Company at Marcus Hook, Pa.

Mr. **R. W. Schultz,** who represents the Minerals Separation Company, Ltd., is at Houghton, Mich.

Mr. **Joseph Stabel,** of Buffalo, has been elected a director of the Inspiration Gold Mines, Ltd., Mr. Stabel has purchased a large interest in the company.

The Chemical Market in the United States in 1916

Coal Tar Products

Production during the year just closed of coal-tar crudes and intermediates has perhaps increased generally in greater proportion than any other department of the chemical industry. The vast work started in the early part of 1915 was successfully and on a broader scale carried on during 1916. Manufacturers of derivatives or coal-tar intermediates have increased in number and during the year practically all intermediates formerly produced in Germany and Switzerland were turned out here in varying quantities and with varying success. The result naturally has been a lowering of market values.

Broadly, these new companies have followed two widely diversified methods of operation. A majority has seemingly lacked the effort of concentration, with the result that a long line of intermediates were produced that as a rule lacked the proper degree of quality. These firms undermined their financial standing, with the result that a number of them passed out of existence, changed ownership or produced a line that promised a larger return. Capital generally was not lacking. The chief difficulties appear to have been the employment of inefficient talent, and the characteristically American effort to turn out a maximum amount in a minimum period resulting in an over-production, mainly of faulty products. New plants were, as a rule, hastily constructed. Apparatus manufacturers beset with raw material problems could not make timely deliveries. The cost of production was difficult to ascertain, and even at the date of writing intermediates are being sold at widely varying figures, reflecting the inability of some manufacturers to arrive at an accurate basis of their overhead.

On the other hand, there have been a number of manufacturers who have concentrated on a small line with the object of improving quality and disregarding quantity. These firms have without exception prospered. Their initial outputs perhaps were far from the standard established by the Germans, but with persistent effort continued improvement has been noted and to-day the American products rank with any produced abroad.

COAL-TAR CRUDES

The production of *benzol* has increased remarkably during 1916, and it is estimated that the total output is now no less than 30,00,000 gal. The number of American coke by-product plants with benzol recovery apparatus is sixty-one. The output for the most part has been absorbed by both manufacturers of intermediates

for dyes and for use in explosives. Exports during the early part of the year, particularly to England, were heavy, though within recent months buying by foreign countries has to an extent been curtailed, with the inevitable result that prices have been subject to a downward tendency. Benzol has now reached the average spot price of 57c. to 60c. per gallon, depending on quantity and individual view. This is a decline of 20c. to 23c. for the year. Contract business is to be had at from 54c. to 55c. However, most of the important producers have sold up a considerable portion of their output and are not now gunning for business.

Toluol has slowly but steadily declined from the high level of $4.80 to $5 a gallon, which prices were in evidence in the early spring of 1916, to the now prevailing price of $1.80 to $2 per gallon for immediate delivery and $1.60 to $1.75 for contracts covering delivery next year. On recent government business one large producer quoted $1.50, and it is known that contracts have been awarded at somewhat less than this figure. The fact that one of the large producers under German ownership has refused to sell a product that would ultimately be used in manufacturing munitions for the Allies has caused a slightly more favorable market for domestic use than for export. Even at the present prices, however, a large margin of profit is shown the manufacturers. The 1916 production is estimated at 8,000,000 gal.

Xylol.—Commercial distilling 90 per cent at 160 deg. has remained comparatively steady at 35c. to 40c., though somewhat keener competition has induced manufacturers to modify their price levels somewhat. The output is small. Spot pure is quoted at $1.20 to $1.25; on contract $1.

Naphthaline has been subject to considerable fluctuation, and from the high level of 17c. to 18c. that was paid for the prime white refined flakes late last winter, the low levels of 6½c. to 7c. were reached during the late summer and fall. Following the import duty of 15 per cent advalorem and 2c. per pound specific imposed recently on imported goods, the local market has strengthened considerably, and domestic manufacturers are quoting from 9c. to 10c., with the English goods held generally at from 10½c. to 11c. There are large surplus stocks available in England, but comparatively small quantities are now reaching this country. The United States production in 1916 is placed at 12,500 tons of refined.

Phenol has had an interesting history during the year, and price changes until recently have been frequent. So great was the demand both from abroad and for domestic account, for use in the manufacture of disinfectants, intermediates for dyes and for explosives, especially picric acid, that nearly twenty new plants started in operation. The increased output, however, combined with a curtailing of the wild demand, was instrumental in bringing prices to lower levels, and several of the new plants went out of existence. The present prices of from 53c. to 55c. show a moderately good profit, considering the cost of raw materials, and with some of the new manufacturers out of the market and a steady volume of demand in evidence, the market shows considerable steadiness, and not a few of the important producers have sold well up on contract. So far thirty-five plants have been equipped with phenol apparatus in this country. One of the operating companies' plant was disposed of at a receiver's sale and has been junked.

INTERMEDIATES

A short summary of the developments of the intermediates is extremely interesting. Chief among the benzol products is ***aniline oil***. With the heavy production of benzol at the outset of the year, and the big demand for dyestuffs and munitions, the output of aniline was greatly accelerated. Production, however, became excessive and a rapid and steady decline in prices was the attendant result. The average cost of manufacture, as computed by important manufacturers based on prevailing price of benzol and nitric acid, is from 26c. to 30c., and with the present price down to the low levels of from 23c. to 22c. of approximately 35 plants operating at the beginning of the year, all but 15 of them have been closed, and not a few have gone out of business altogether. The present price of aniline oil represents a decline of about 75c. for the 12 months, the year having opened at $1. Definite figures of the American production of aniline oil are not available, but it is estimated that a year's output is now approximately 20,000 tons. As a result of high standards demanded of American manufacturers by aniline oil consumers at the beginning of the war, the quality of oil produced here has been higher than any previously marketed.

Aniline Salts.—This market has followed more or less closely the vicissitudes of the aniline oil market, and prices have dropped toward the end of the summer and since in proportion to the declines in oil. Compared with the consuming demand for salts, production has been more or less heavy, and as the year closes the prevailing price is from 28c. to 30c. for spot deliveries of hydrochloride.

Nitro Benzol (Oil of Myrbane).—Much of the domestic production of this benzol product was more or less unsatisfactory early in the year, as a considerable portion of the output of some factories had not been up to standard and many rejections were made. At present the outside market is dormant, with 16½c. to 17c. the prevailing price for the prime commercial, and up to 18c. for the refined.

Toluidine, the chief dye intermediate made directly from toluol, is being produced by perhaps half a dozen manufacturers with varying success. At the present time there are but two producers who are separating it into the para and ortho, and these only in a limited way, owing to the manufacturing difficulties encountered in the separating process. One large producer whose toluol is costing but a fraction of the ruling market price, is preparing to make the ortho and para.

Xylidine.—Due to the fact that supplies of xylol had not been particularly abundant, and the relatively small yield of the xylidine, production has not been particularly successful, and there are few manufacturers who have been able to turn out supplies in a commercial way.

Picric Acid was subject to wild speculation at the beginning of the war, but this subsided more or less during 1916. There were not the fabulous orders for foreign government nor the wild promises of manufacture that obtained earlier in the situation, and although there were some important orders placed for South American governments, as well as for the Allies, the business was well centered in comparatively few hands.

Trinitro-toluol was produced by but six large manufacturing concerns, and while the orders were not as heavy as in the preceding year, some large business has been placed, usually at somewhat lower levels. On recent United States ordnance department bids, the lowest proposed for the crude T.N.T. was 43c., and for the refined 63.5c.; both prices f.o.b. works.

Of the nitro compounds used in the manufacture of dyes, *paranitraniline* came in for most attention. Several manufacturers have within recent months started operations, but the majority of these are far behind in deliveries. This fact together with the heavy demand

both for domestic account and for export has kept the price at high levels. Supplies even now are scarce, and spot goods command from $1.60 to $1.70 per pound, with contract quoted at from $1.15 to $1.30, depending on seller and length of contract. Little interest, however, is now shown in future positions by consumers.

Dinitrotoluol is being made on a comparatively large scale, but manufacturers are chiefly using the product for their own consumption. Large explosive manufacturers are quoting at from 55c. to 60c. for important business.

Of the primary amines and derivatives, *alpha naphthylamine* commanded special attention. Large dye manufacturers have been using their output in their own processes, and independent manufacturers have at all times found a ready market for their supplies. Spot price ranged with moderate steadiness at $1.25 per pound for immediate delivery, and from $1 and up on contract.

Dimethyl aniline of the secondary amines and derivatives has been quiet, and prices have gradually been subject to declines, the prevailing levels being 55c. to 60c.

Diphenylamine.—The chief use for this has been as an explosive stabilizer, although some demand for use in dyes was noted. The production has been extremely limited, and important producers have sold up on contract.

Among the diamine group, *paraphenylamine diamine* has been subject to most demand, and the limited production keeps the price at the relatively high levels of from $3.25 to $3.75 for immediate deliveries.

Metaphenylene diamine production has been nominal, and the limited output has been rapidly absorbed by dye makers.

Metatoluylene diamine is being produced in a few isolated cases by outside manufacturers, but by far the larger proportion of output has been by dye makers who consume their own product.

Betanaphthol has been produced on a large scale, and the number of manufacturers has been increased to about twenty. Heavy demand at the beginning of the year kept the price high at from $1.75 to $2 for the technical, and up to $2.50 and $2.75 for the sublimed, depending on seller and conditions of sale. The increased production, however, together with a lessening of demand, caused prices to drop to their present level of from 80c. to $1.

The amido phenols and derivatives attracted considerable attention, particularly *H acid* (*amido naphthol disulphonic acid*), which is in keen demand, with restricted production owing to difficulties in manufacture. The two largest producers have and are using the product for their own consumption. Important foreign and domestic orders are unfilled, as supplies are not obtainable. Preparations are being made to turn out this product on a fairly large scale, and promises are made that the situation will be less tense in the future.

Salicylates have weakened gradually owing to over supplies and the prices have dropped from levels in the neighborhood of $4 to the present prices of from $1 to $1.15, for both the *sodium* and *salicylic acid*. *Salol* has declined from the high level of $9 in second hands to the prevailing price of $2.25 to $2.30.

DYESTUFFS

Activity during the year was confined to transactions in surplus German stocks and to an increased production of domestic colors.

Foreign Dyes.—Swiss and French colors were imported, but rarely reached the open market as shipments to this country were invariably sold prior to arrival. While there has been no absolute scarcity as far as bulk is concerned of German colors during the year, prices have again ruled high, many hundred per cent above those prevailing before the war. With the possible exception of the alizarin colors, there was little difficulty noted in obtaining the various type productions at a price. Of the foreign colors, reds and blues, were at all times in brisk demand, but a good call was noted for a full line. Rhodamine B and 6G, eosine, fuchsine, Bismarck brown R and Y and primuline were colors mostly in demand during the latter part of the year. Prices toward the close of the year were lower than at any time since the beginning of the war. The two visits of the under-sea merchant vessel "Deutschland," carrying dyes and chemicals, came in for much public attention. The cargo on the first trip was much exaggerated. In tonnage it did not exceed three days' requirements of the entire American consuming industry. The colors, however, were concentrated, so that possibly the cargo represented four or five days' supplies for our textile and other color-consuming mills. No definite information has so far come to hand in regard to the bulk or the concentration of the "Deutschland's" second cargo. Unless a number of under-sea vessels are to engage regularly in this traffic, American color manufacturers do not look for very serious competition from this direction while the war lasts.

Domestic Dyes.—Blacks, of course, came in for most attention. A large number of concerns began the manufacture of sulphur black. Many difficulties were encountered, owing to inexperience and the difficulties of securing raw materials. Some very inferior color reached the market. Rejections, however, were seemingly the best development the trade had. It soon became evident that a good fast color must be produced or operations must cease, and good fast colors were turned out. A high percentage of the sulphur black produced to-day ranks well up with that of Continental Europe. Toward the end of the year one of the large explosive manufacturers not heretofore manufacturing colors began the delivery of this color. Other colors will shortly be marketed. Direct black, from a market viewpoint, probably attracted more attention than any other color during the year. Domestic manufacturers could not turn out sufficient material to answer the requirements of the trade and sales of a well-known brand were made above the $2 level. Two and one-half years after the outbreak of the European war finds the American dye maker turning out practically a full line of aniline colors, with a few manufacturers producing from an anthracene base and vast experimental work progressing on all lines. The government census of dyestuffs came as an invaluable aid to the manufacturer here, who had been working entirely in the dark. There was no method of ascertaining the consumption of any one intermediate or color. The census allowed of a vast amount of analytical work. For example, orange II (sodium salt of p-sulphobenzol-azo-beta-naphthol), a popular color, not difficult to manufacture, is now selling for approximately $3, prompt delivery. For contracts domestic manufacturers quote $1. The imports of this color for the 1913-1914 fiscal year were 127,550 lb., valued at $10,116. This is an average of $0.079 per pound. It should be borne in mind, however, this price is net in bulk at German shipping point, does not include duty, containers, transportation or other incidental charges. Under the new tariff, effective at the close of the war, this color as well as all others will be protected by only a 35 per cent duty. Exports of domestic dyes and dyestuffs reached an amazing proportion. For the nine months ending September a

total outward business of some $5,265,000 had been transacted. These colors went to practically every neutral country and the states of the Entente. Doubts are expressed as to whether American exporters can maintain this trade after the end of the war.

Heavy Chemicals

The output of practically every product in this classification during 1916 was the heaviest in the history of the industry.

Potassium Salts.—As compared with 1915, the past year was a comparatively tame one, in regard to the sale of surplus stocks of German potash. Supplies had dwindled to such small proportions that large transactions were no longer possible. For such small quantities of "muriate" as have been available up to $500 had been paid, with a recession in price toward the end of the year. Some attention is now being given to the Japanese product, which is to be had at considerably lower prices. Sales, however, have been principally confined to chemical manufacturers of potassium salts. The search for potash within the United States has so far resulted in a production from kelp, cement, alunite, feldspar, and from natural deposits, of 45 tons daily of K_2O. One-half, or possibly more, is produced from the natural deposits of the Nebraska lakes. A production of 45 tons per day is about 6 per cent of the average daily consumption of K_2O in normal times.

Ammonium Salts.—Although no definite figures are yet available, the production of *ammonium sulphate* was unquestionably the largest in the history of the American industry, as a larger number of by-product coke plants were operated than ever before, and supplies of British sulphate were cut off, owing to the governmental embargo. Of the other ammonium salts, *nitrate* came in for a vast amount of prominence, for the manufacture of high explosives. The seven or eight American producers for the first six months of the year had considerable difficulty in fulfilling contract requirements. In the early fall there was a lull in the situation, with declining prices, but subsequently a sharp recovery was noted. At the present time exports, particularly to France and Italy, are exceedingly heavy, and large factors are quoting higher prices for contract than the prevailing spot figures.

Nitrate of Soda.—For the first time in the history of the industry the imports of nitrate of soda from Chili exceeded the million-ton mark. Prices ruled on high levels, opening the year at $3.25 per cwt., and closing at near $3.40. Sulphate of ammonia and nitrate of soda usually compete on a basis of unit of ammonium content, but owing to abnormal conditions prevailing, supplies of the sulphate were limited, and this situation did not exist during 1916 to any considerable extent.

Mineral Acids.—As the imports of sulphur ore (pyrites) for the nine months ending September, 1916, were in excess of the million-ton mark, it is quite safe to assume that the production of *pyrites Sulphuric acid* was again greater than the high-water mark of the previous year. The domestic and Canadian production of pyrites was also reported to have been larger than for any corresponding period. Brimstone acid has been subject to a heavier demand than ever before for use in explosives, and also in the manufacture of dyes. Early in the year prices ruled at high levels, but as production increased there was a let-up in the keen demand, and slowly but surely the price levels receded. For the last few months, however, there has been increasing call for the acid, and at the present time there is an actual scarcity; many important manufacturers are not taking business for prompt delivery at this time, having well sold up on contract. There has been much complaint regarding the poor quality of the pyrites acid produced in the South. Acid prices have varied considerably, depending largely on location of plant. Northern producers are quoting from $26 to $28 per ton for the 66-deg. brimstone, and from $16 to $18 per ton for the 60-deg. brimstone. Pyrites acid is held at high levels, and Southern manufacturers are asking up to $18 and $20 per ton for the 66-deg. grade, f.o.b. plant. The price for the 60-deg. pyrites ranges from $12 to $15 per ton at works.

Muriatic Acid.—Demand for this acid has been spasmodic, although there has not been the recent advances that obtained in the sulphuric market. Some big orders have been placed lately, however, especially for contract. The 20-deg. goods are quoted at from 1⅜c. to 1½c., and up to 1⅝c. and 1¾c. for the 22 deg.

Nitric Acid.—Early in the year there was heavy demand in evidence, but since the late summer prices have gradually eased off, owing to the fact that production had increased, without the corresponding expansion of demand. The condition has improved during the last month, however, in sympathy with the changed sulphuric situation, and at present the 42-deg. grade is quoted at about 6c., and the lower concentrations at proportionately lower prices. Owing to the dangerous quality of the higher strengths, but few manufacturers are willing to concentrate above the 42-deg. mark, and prices on these grades rule high.

Organic Acids.—Acetic acid, glacial, started off in January, 1916, at about 30c. to 32c., and after some fluctuation, followed by gradual declines last spring, the low mark of 15c. was reached in October, when a complete metamorphosis occurred in the situation, and almost over night in the middle of November the price jumped to 30c., and has advanced to the present price of from 33c. to 35c. Heavy export demand, coupled with the starting of a strike at the plant of one of the largest producers, created the change. The 80 per cent grade is in heavy demand and has increased from the price of 7½c. to 8c. prevailing in November to the present figures of 14c. for the commercial, 16c. for the redistilled, and up to 17c. for the pure. The lower strengths advanced in sympathy, although little demand is in evidence.

Lactic Acid.—The market continues rather steady, at 5c. to 5¼c. for the pale 22-deg. rectified.

Phosphoric Acid.—Supplies are nominal, and have been for some time; the few domestic producers are well sold up into the future, and but limited supplies of the 47 to 50 per cent liquid are to be had at 13c. to 14c.

Oxalic Acid.—Steady imports from Norway and Holland, added to the increased domestic production, have caused an oversupply on the market, and following gradual declines the prevailing prices to-day range from 43c. to 48c., depending on grade.

Cyanides.—The fact that the electrical power of the only large producer of cyanides in America was curtailed recently has caused a wildly speculative market, with attendant soaring prices. From the price of 25c. to 30c. for sodium prevailing at the outset of the year, gradual advances obtained, until within the last three weeks prices jumped from 80c. to the abnormal figures of $1.75 and $1.80. The potassium is even higher in price, and sales were recorded just prior to the holidays at $2.05 per pound. The demand is still heavy for mining operations, and supplies are nominal.

Chromium Salts.—These chemicals have had most particularly interesting careers during 1916. At the beginning of the year potassium bichromate was held at 45c., and increased gradually until in the spring the high levels of 90c. to 92c. for potassium and 65c. to

68c. for sodium were reached. During this time there was keen speculation in evidence, and manufacturers were having difficulty in filling orders. However, realizing the abnormal condition of the market and susceptibility to influences, manipulation began, in order to purchase resale supplies that they might be turned at a profit on orders. The market weakened under this pressure and gradually was reduced to the levels that now prevail, viz., from 40c. to 42c. for potash. Supplies which never were abundant are at this time scarce, and held with some firmness.

The present market in bichromate of soda is uncertain. The lowest figures that have obtained at any time during the year prevail. From 19c. to 20c. are the prices to-day. At the start of the year the price was 25c., which increased under heavy speculative demand to abnormal levels in the spring, receding gradually throughout the year to the present levels. One of the largest consumers in the country is now making its own chromium salt. Consumers generally had well contracted for their supplies. A Canadian owned production now competes with domestic manufacture. The general output has increased to a marked degree. The skillful manipulation has brought prices to their present levels. So great was the speculation during the high levels that many small buyers were caught, and heavy losses were incurred.

Copper Sulphate.—There has been a moderately strong demand all during the year, with high prices ruling, particularly during March and April. The output of the three largest producers is well sold up, and supplies in second hands are now more or less moderately small. Anticipated orders from abroad, however, especially from Greece, for use in spraying vineyards, not having materialized, the market is somewhat easier at present, and the large 98 to 99 per cent crystals are available at from 12c. to 12½c.

Alkalis.—Caustic soda, of course, has been traded in to an enormous extent, and the consuming demand has been on a large scale all during the year; this has been a highly speculative article, and gambling interests have played an important part in the price movements. Prices ranged from 5½c. to 5¾c. in January, 1916, to 6⅝c. and 6⅞c. in March, to the levels of 4.35 to 4.45 that now obtain. The fact that three new manufacturers have entered or are about to enter the field is also an important factor in bringing about the present prices. Contract business is almost at a standstill compared to usual activity. Producers are standing "pat" in an endeavor to keep the prices up.

Soda Ash.—Following the recent peace rumors, the market has receded somewhat, although as much of the large manufacturers' supplies are under contract; there is no pressing of stocks for sale. The spot price ranges from $3.05 to $3.10 for the 58 per cent light, flat basis, and on contract over 1917 at from $2.65 to $2.70. Some sales were made several weeks ago for 1918, but consumers are not booking business now so far into the future. At least two large important new producers entered the field.

Bleaching Powders.—The market for the last several months has shown steady declines from the high prices that were in evidence at the beginning of the year, which opened at 14c. to 15c. The difficulty of securing adequate supplies of drums suitable for export has increased perceptibly as time advanced. The spot price for bleach in large domestic drums is now 4½c., and for good export drums from 6⅜c. to 6⅝c., showing a difference of a full 2c. per pound for the different packing. Export demand is rather spotty, but generally heavy, Scandinavia and England, particularly, buying in large quantities for their paper and pulp mills. The present manufacture of bleach in this country has been fairly well contracted for by consumers and dealers, and supplies offered on the open market are therefore limited. The production of bleaching material by consumers for their own use increased as never heretofore.

CURRENT MARKET REPORTS

The Iron and Steel Market

The second half of December witnessed a sudden and marked slowing down in the iron and steel markets. Production continued at the fullest rate, except as curtailed by insufficient transportation facilities, many furnaces being banked through coke being slow en route, or through coke operators not having cars into which they could draw their ovens. Apparently the slowing down started with the German peace overture, which became public news on December 12, but there had previously been predictions that steel bookings would be much lighter in December than they had been in November, when the Steel Corporation's unfilled tonnage increased by a million tons only for the third time in the corporation's history. The advent of the holidays always slows down market activity, and thus there has been a combination of circumstances.

The iron and steel producers are little concerned with the market, their chief concern being the filling of the orders already on books, as there is prospect of a railroad blockade throughout the winter as severe, possibly more severe, than that of 1902-3, which railroad men pointed out at the time was the first in the history of American railroading, and might prove to be the last.

The common complaint is "car shortage," that being what the shipper experiences. It cannot be admitted, however, that there are fewer cars in the country than would be needed to carry the freight if they were loaded approximately to capacity and if they were kept in service. There has been no general increase in the minimum load for iron and steel products in about 17 years, practically the life of the steel-car industry. During that period the railroads have spent enormous sums replacing cars of small capacity with cars of greater capacity, but in many instances use is not made of the increased capacity. Consignees have been using cars for storage purposes, unloading their goods when they were ready, as $1 a day for warehouse facilities, paid for when needed, and costing nothing when not used, proved a small expense. The demurrage rates were greatly increased Dec. 15, and this may help. The railroads are certainly short of motive power, and the inadequacy of motive power was particularly great when cold weather arrived, as locomotives that were able to get along in mild weather played out completely in cold weather.

Early in December a proposition was made that the iron and steel industry should shut up shop for a week or ten days to allow the railroads to clear their lines. The industry had no machinery even for adopting such a program, much less for carrying it out, while the desire probably was lacking owing to natural doubt as to the efficacy of a remedy never before tried. As car shortages have proved most serious in the Connellsville coke region, an automatic slowing down is probably in process. Beginning the week before Christmas, a number of furnaces were banked, and the number has increased steadily since then. Some of the steel works, however, have moderate stocks of pig iron, but the use of cold iron itself slows down production a trifle.

PIG IRON

A few advances in pig iron, practically negligible, have occurred since last report. The market is substantially at a standstill, with producers almost fully sold for the first half of 1917, and with very considerable tonnages on their books for the second half. As prices are easily the highest since 1880, and the excitement is over, a quiet market is to be expected for some time, except for the buying of some descriptions of pig iron in small lots for prompt shipment at a premium.

UNFINISHED STEEL

Unfinished steel has advanced about $5 a ton since last report. Market prices are made by occasional sales, sometimes merely by bids. The buying demand has been narrow, but the offerings have been still scantier. Ordinary soft-steel billets and sheet bars are now quoted at $60 to $65, Pittsburgh or Valley, the lower price being readily bid for export, while it appears that the higher price has been paid occasionally for prompt lots. Wire rods command $75 to $80, the higher price having been paid on a round lot for export to Canada. Why wire rods should bring so much more than the billets from which they are made and the wire products they are customarily made into is not readily explained. At $75 per gross ton, wire rods are 3.35c. per pound, or more than the base price of either plain wire or nails. Forging billets are quoted at $80 to $85.

FINISHED STEEL

The sheet market has continued to stiffen, and while prices for late deliveries may not be quotably higher, it is certain that higher prices are obtained for early deliveries than a fortnight ago. Otherwise, the finished-steel market is substantially unchanged as to prices, except for the advance of $2 a ton in bars, shapes and plates, to 3c., 3.10c., and 3.60c. respectively, which occurred about Dec. 20. This advance, however, can hardly be viewed in the same light as the various advances that preceded it. They occurred, except perhaps as to certain advances early last August, when the buying pressure was extremely heavy, while this advance occurred when the market had been distinctly quiet for a week. Students of steel market history will perhaps feel the atmosphere of old times, for at the end of a general price-advancing movement there has usually been a last advance which served to "clinch" or make sound the business placed on books at the next lower prices.

IRON ORE

December shipments of Lake Superior iron ore down the lakes were unprecedentedly heavy, amounting to 1,085,900 tons, and bringing the season total by lake to 64,734,198 tons. As more than 1,500,000 tons was doubtless moved by all-rail routes, the total shipments of the Lake Superior region, on the American side, must have exceeded 66,000,000 tons, against 47,000,000 tons in 1915, and 50,000,000 tons in 1913, the record year. There is no possibility, therefore, of there being a scarcity of iron ore in the winter or spring, fears as to which were expressed last spring. It is coke and limestone that are giving the blast furnaces their anxious time.

Non-Ferrous Metal Market

Dec. 26.—The chief factor influencing the market during the past two weekst has been the peace talk, and while some of the metals, especially lead and tin, have remained firm, buying has been curtailed to a great extent. The holiday season also had its effect, as buying is normaly dull during the last two weeks of the year. The drop in the stock market did not have such a great effect on the copper market as was anticipated, owing to the sold-up condition, but it did have the effect of inducing some consumers to sell surplus stocks which they had on hand.

Copper.—Since Dec. 11, on which day copper reached its highest point of 36c. for prompt electrolytic, the price has dropped, and electrolytic and Lake are now quoted at 31c. to 32c. for prompt delivery. New copper restrictions were put in effect in England, allowing no one to buy outside the United Kingdom without a permit, and the use of copper is forbidden except for government work. Business has been dull, with the exception of some reselling by consumers. Buyers are holding off until next year, and producers are believed to be pretty well sold up for the biggest part of next year, making it difficult to see how prices can go very low for some time to come. Exports up to Dec. 22 were 17,763 long tons.

Tin.—Straits tin has declined from 43.50c. on Dec. 11 to 40.50c. on Dec. 22. The London market has also declined considerably during the last two weeks, and £185 is quoted for prompt Standard and Straits. Insurance rates on shipments are higher, and arrivals continue to be light. As in the case of the other metals, the peace talk and the holidays have curbed buying. Several hundred tons of Banca tin arrived Dec. 21, and was offered at 40.50c., which is the present spot quotation for Straits.

Lead.—The lead market has remained strong in spite of the peace talk, and no January or February lead at the trust price of 7.50c. is to be had. Independents have cut their prices slightly from 7.75c. to 8c., down to 7.50c. to 7.62½c.

Spelter.—The peace talk stopped trading in the spelter market, and prompt spelter has declined from 12.30c. on Dec. 11 to 10.05c. on Dec. 22. Buyers are holding off, awaiting developments. Zinc-ore prices are lower, and producers showed more disposition to sell on Dec. 22, resulting in a small amount of business at lower prices.

Other Metals.—Antimony remains unchanged in price at 14.37½c. for Japanese and Chinese. The market has been dull. Aluminum is quoted at 60c. to 64c. for No. 1 virgin metal. Magnesium remains at $3.50 per pound, electrolytic nickel at 50c., and cadmium at $1.50. Platinum is quoted at $99 per ounce, tungsten ore at $17.50 to $20.00 per unit, and silver at 75¾.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DECEMBER 7.

Acetone, Drums	lb.	.22½	—	.23
Acid, acetic, 28 per cent	100 lb.	3.50	—	3.65
Acetic, 56 per cent	100 lb.	7.00	—	7.15
Acetic, glacial, 99½ per cent, carboys	lb.	.25	—	.30
Boric, crystals	lb.	.12¾	—	.13½
Citric, crystals	lb.	.65	—	.67
Hydrochloric, commercial, 18 deg	lb.	.01¾	—	.02
Hydrochloric, 20 deg	lb.	.02	—	.02¼
Hydrochloric, C. P., conc., 22 deg	lb.	.02¼	—	.02½
Hydrofluoric, 30 per cent, in barrels	lb.	.05	—	.05½
Lactic, 44 per cent	lb.	.14	—	.15
Lactic, 22 per cent	lb.	.07	—	.07½
Nitric, 36 deg	lb.	.06¼	—	.06½
Nitric, 42 deg	lb.	.07	—	.07¼
Oxalic, crystals	lb.	.47	—	.50
Phosphoric, 85 per cent	lb.	.29½	—	.30
Picric	lb.	.75	—	.85
Pyrogallic, resublimed	lb.	3.25	—	3.45
Sulphuric, 60 deg	lb.	.01½	—	.01¾
Sulphuric, 66 deg	lb.	.01¾	—	.02
Sulphuric, oleum (Fuming), tank cars	lb.	.02	—	.02¼
Tannic, U. S. P. bulk	lb.	.90	—	1.05
Tartaric, crystals	lb.	.66	—	68
Alcohol, grain, 188 proof	gal.	2.70	—	2.72
Alcohol, Wood, 95 per cent	gal.	.90	—	.92
Alcohol, Denatured, 180 proof	gal.	.64	—	.65
Alum, ammonia lump	lb.	.04	—	.04¼
Alum, chrome	lb.	.25	—	.26
Alum, potash lump	lb.	.05¼	—	.08
Aluminum sulphate, technical	lb.	.03½	—	.04
Aluminum sulphate, iron free	lb.	.05	—	.05½
Ammonia aqua, 26 deg. carboys	lb.	.06	—	.06¼
Ammonia, anhydrous	lb.	.25	—	...
Ammonium carbonate	lb.	.11	—	.12
Ammonium, nitrate	lb.	.12½	—	..
Ammonium sulphate, domestic	lb.	.04¼	—	..
Amyl acetate	gal.	4.50	—	4.75

Antimony salt, 75 per cent		.. — ..
Antimony salt, 65 per cent		.. — ..
Antimony salt, 47 per cent		.. — ..
Argols	lb.	.08 — .09
Arsenic, white	lb.	.07¾ — .08½
Arsenic, red	lb.	.65 — .70
Barium chloride	lb.	05 — .05¼
Barium sulphate (Blanc Fixe) powder	lb.	.04½ — .05
Barium nitrate	lb.	.15 — .16
Barium peroxide	lb.	.38 — ..
Bleaching powder, 35 per cent	lb.	.04¼ — .06¼
Borax, crystals, sacks	lb.	.06¾ — .07
Brimstone, crude	ton	28 50 — 29.00
Bromine, technical	lb.	1.40 — ..
Calcium acetate, crude	lb.	.03½ — ..
Calcium carbide	ton	73.00 — 75.00
Calcium chloride, 70-75 per cent, fused, lump	ton	23.00 — 26.00
Calcium chloride, granulated		.. — ..
Calcium peroxide	lb.	1.50 — ..
Calcium sulphate	lb.	.10 — .2=
Caclium phosphate	lb.	.30 — .35
Carbon bisulphide	lb.	.05½ — .06½
Carbon tetrachloride, drums	lb.	.16½ — .17
Caustic potash	lb.	.78 — .90
Caustic soda, 76 per cent	lb.	.04½ — .05
Chlorine, liquid	lb.	.15 — .24
Copperas	100 lb.	1.25 — 1 50
Copper carbonate	lb.	.45 ..
Copper chloride (cupric)	lb.	.55 — .60
Copper cyanide	lb.	.70 — ..
Copper sulphate	lb.	.14 — ..
Cream of tartar, crystals	lb.	.39½ — .41
Epsom salt bags	100 lb.	1.75 — 2.00
Formaldehyde, 40 per cent	lb.	.12 — .12½
Glauber's salt	100 lb.	.75 — .85
Glycerine, bulk	lb.	.55 — .56
Hydrogen peroxide, gross		6.50 — 18.00
Iodine, resublimed	lb.	4.25 — 4.30
Iron oxide	lb.	.13 — .15
Iron sulphide	lb.	.04 — .05
Lead acetate, white crystals	lb.	.13 — ..
Lead arsenate	lb.	.08 — .09
Lead nitrate	lb.	.15½ — .16
Litharge, American	lb.	.09¼ — ..
Lithiun carbonate	lb.	1.02 — 1.05
Manganese dioxide	lb.	.70 — .75
Manganese borate	lb.	.36 — .39
Manganese chlorate	lb.	.. — ..
Manganese sulphate	lb.	.. — ..
Magnesium carbonate, tech	lb.	.13 — .14
Nickel salt, single	lb.	.14 — ..
Nickel salt, double		.11½ — ..
Phosporus, red	lb.	1.00 — ..
Phosphorus, yellow	lb.	.80 — ..
Potassium bichromate	lb.	.42 — .42½
Potassium bromide grnular	lb.	1.35 — ..
Potassium carbonat calcined, 80-85 per cent	lb.	.38 — .40
Potassium chlorate, crystals	lb.	.67 — .70
Potassium cyanide, 98-99 per cent	lb.	Nominal
Potassium idodide	lb.	3.40 — 3.50
Potassium muriate, 80-85 p. c., basis of 80 p. c.	ton	450.00 — 460.00
Potassium nitrate	lb.	.32 — .33
Potassium permanganate	lb.	3.00 — 3.50
Potassium prussiate, red	lb	2.50 — 2.75
Potassium prussiate, yellow	lb.	.92½ — .95
Potassium sulphate, 90-95 p. c., basis 80 p. c	ton	275.00 — 300.00
Rochelle salts	lb.	.34 — ..
Sal ammoniac, gray, gran	lb.	.10 — .15
Sal ammoniac, white, gran	lb.	.17½ — .20
Sal soda	100 lb.	1.10 — 1.25
Salt cake	100 lb.	.75 — ..
Silver cyanide	lb.	.70 — .71
Silver nitrate	oz.	.47½ — .49½
Soda ash, 58 per cent, light, flat	lb.	.03 — .03⅛
Soda ash, 58 per cent, dense, flat	lb.	.03¾ — .04
Sodium acetate	lb.	.14 — ..
Sodium benzoate	lb.	8.25 — 8.75
Sodium bicarbonate, domestic	100 lb.	1.75 — 1.90
Sodium bicarbonate, English	lb.	.03 — .03½
Sodium bichromate	lb.	.21 — .22
Sodium bisulphite, powd	lb.	.05½ — .06
Sodium chlorate	lb.	.28 — .30
Sodium cyanide	lb.	.28 — .70
Sodium fluoride, commercial		.. — ..
Sodium hyposulphite	lb.	.01¾ — .02¼
Sodium nitrate, refined	lb.	.31 — .35
Sodium nitrite	lb.	.18 — .20
Sodium peroxide		.. — ..
Sodium phosphate	lb.	.05 — .06
Sodium prussiate	lb.	.34 — .36
Sodium silicate, liquid	100 lb.	.85 — 1.00
Sodium sulphide, 30 per cent crystals	lb.	.02¼ — ..
Sodium sulphite		.. — ..
Strontium nitrate	lb.	.28 — .30
Sulphur chloride		.. — ..
Sulphur, flowers, sublimed	100 lb.	2.50 — 2.70
Sulphur, roll	100 lb.	1.95 — 2.25
Sulphur, crude	ton	29.50 — ..
Tin bichloride, 50 deg	lb.	.15 — .15½
Tin oxide	lb.	.48 — .50
Zinc carbonate	lb.	.25 — .27
Zinc chloride	lb.	.10¼ — .11½
Zinc cyanide	lb.	.50 — ..
Zinc dust	lb.	.24 — .30
Zinc oxide, American process	lb.	.09¾ — .09⅞
Zinc sulphate	lb.	.07½ — .08

Coal Tar Products (Crude)

Bensol, pure, water white	gal.	.60 — .65
Bensol, 90 per cent	gal.	.60 — .65
Toluol, pure, water white	gal.	1.75 — 2.25
Xylol, pure, water white	gal.	1.00 — 1.20
Solvent naphtha, water white	gal.	.25 — .35
Solvent naphtha, crude heavy	gal.	.20 — .22
Creosote oil	gal.	.12 — .15
Dip oil	gal.	.30 — .34
Pitch, various grades	ton	14.00 — 16.00
Carbolic acid, crude, 95 per cent	lb.	.95 — 1.05
Carbolic acid, crude, 50 per cent	lb.	.65 — .70
Carbolic acid, crude, 25 per cent	lb.	.30 — .34
Cresol, U. S. P	lb.	.19 — .21
Cresylic acid, refined No. 5	lb	.18 — .20

Intermediates, Etc.

Alpha naphtylamine	lb.	.. — 1.25
Aniline oil	lb.	.23 — .26
Aniline salts	lb.	.35 — .38
Anthracene, 80 per cent	lb.	.. — .10
Benzaldehyde	lb.	.. — 5.25
Benzidine	lb.	1.90 — ..
Benzoic acid	lb.	.. — 8.00
Beta naphthol	lb.	.. — 1.15
Dichlor benzcl		.. — ..
Dimethylaniline	lb.	.. — .58
Diphenylamine	lb.	.. — 1.00
H-acid	lb.	.. — 2.25
Metaphenylenediamine	lb.	.. — 1.75
Monochlorbenzol		.. — .33
Naphthalene	lb.	.09 — .10
Naphthionic acid, refined	lb.	2.25 — ..
Naphthionic acid, crude	lb.	1.05 — ..
Ortho-amidophenol		.. — ..
Ortho-toluidine	lb.	1.75 — ..
Para-amidophenol	lb.	8.00 — 8.50
Paranitraniline	lb.	.. — 1.75
Paraphenylenediamine	lb.	.. — 4.00
Para toluidine	lb.	2.25 — ..
Phenol, U. S. P.,	lb.	.53 — .55
Resorcin, technical	lb.	9.00 — ..
Resorcin, pure	lb.	25.00 — 26.00
Salicylic acid	lb.	1.00 — 1.15
Salol	lb.	2.30 — 2.40
Sulphanilic acid	lb.	.. — .40
Toluidine-mixture	lb.	.. — 2.00

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania	bbl.	2.75 — ..
Corning, Ohio	bbl.	2.20 — ..
Somerset, Ky	bbl.	2.10 — ..
Wooster, Ohio	bbl.	1.75 — ..
Indiana	bbl.	1.38 — ..
Illinois	bbl.	1.57 — ..
Oklahoma and Kansas	bbl.	1.20 — ..
Caddo, La., light	bbl.	1.20 — ..
Corsicanna, Tex., light	bbl.	1.10 — ..
California	bbl.	.74 — ..

LUBRICANTS

Black, reduced, .29 gravity, 25-30 cold test	gal.	.13½ — .14
Cylinder, light		.21 — .26
Cylinder, dark		.18 — .19
Extra cold test		.26 — .31
Paraffine, high viscosity		.29½ — .30
Paraffine, .903 spec. gr		.21½ — .22
Paraffine, .865 sp. gr		.18½ — .19

Flotation Oils

Pine oil, steam distilled	gal.	.58 — ..
Pine oil, destructively distilled	gal.	.46 — ..
Pine-tar oil	gal.	.19 — ..
Pine-tar oil, double refined	gal.	.27 — ..
Pine oil, light	gal.	.37 — ..
Pine oil, heavy	gal.	.26 — ..
Pine tar, thin	gal.	.18 — ..
Turpentine, crude	gal.	.38 — ..
Hardwood oil, f.o.b. Michigan	gal.	.16 — ..
Creosote, coal tar, neutral	gal.	.15½ — ..
Creosote, coal tar, acid	gal.	.21½ — ..
Coal tar, thin	gal.	.11 — ..

Vegetable and Other Oils

China wood oil	gal.	.12 — .12¼
Cottonseed oil, crude	gal.	.82 — .83
Linseed oil, raw	gal.	.92 — ..
Peanut oil, crude	gal.	.88 — .90
Rosin, 280 lb	bbl.	6.55 — ..
Rosin oil, first run	gal.	.38 — ..
Soya bean oil, Manchuria	gal.	.11¾ — .12¼
Sperm oil, bleached winter, 38 deg	gal.	1.00 — 1.02
Turpentine, spirits	gal.	.55 — .56

Miscellaneous Materials

Barytes, floated, white	ton	25.00 — 35.00
Beeswax, white, pure	lb.	.45 — .50
Carnauba wax, highest grade	lb.	.50 — .52
Chalk, light, precipitated, English	lb.	.04½ — .05½
Feldspar	ton	8.00 — 12.00
Fuller's earth, powdered	100 lb.	.80 — 1.05
Plaster of Paris	bbl.	1.50 — 1.70
Red lead, dry, carloads	lb.	.. — .09¾
Soapstone	ton	10.00 — 12.50
Talc, American, white	ton	10.00 — 13.00
White lead, dry	lb.	.. — .09¾

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick	net ton	120.00 — 130.00
Chrome cement, Grecian	net ton	80.00 — 90.00
Clay brick, 1st quality fireclay	per 1000	40.00 — 50.00
Magnesite, Grecian, dead burned	net ton	85.00 — 90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00 — 140.00
Silica brick	per 1000	40.00 — 45.00

Ferroalloys

Ferro-carbon-titanium, carloads	lb.	.08 — ..
Ferrochromium		Nominal
Ferromanganese, domestic, delivered	ton	.. 175.00 ..
Ferromolybdenum	lb.	4.00 — ..
Ferrosilicon, 50 p. c., carloads, del. Pittsburgh	ton	100.00 — ..
Ferrotungsten, 75-85 p. c., f.o.b. Pittsburgh	lb.	2.30 — ..
Ferrovanadium, f.o.b. works	lb.	2.75 — 3.00

INDUSTRIAL

Financial, Construction and Manufacturers News

Financial

Alaska Hydraulic Mines, Inc. Catipal, $1,000,000. Incorporated in Delaware to mine gold, silver, copper, lead, zinc, etc., by Norman P. Coffin, Herbert E. Latter and Clement M. Egner, all of Wilmington.

The Alabama Wood Oil Company, Mobile, Ala., has been incorporated with a capital of $15,000 to manufacture wood, animal and mineral oils. The incorporators are O. E. Childs, Moline, Ill.; J. E. Drysdale, W. W. Bailey, Davenport, Iowa, and the American Wood Oil Co., Wilmington, Del.

Amber Chemical Corporation, New York, has been incorporated with a capital of $30,000 to manufacture chemicals and drugs. Incorporators are A. Sinclair, 15 Wall Street, New York; A. L. Bykeeper, 1642 Decatur Street, Brooklyn; C. G. Francis, 15 Wall Street, New York.

Anthony-Hammond Chemical Works, Inc., New York, has been incorporated with a capital of $100,000 to manufacture benzoate, beta napthol products, etc. The incorporators are E. N. Carey, M. Tischeer, H. C. Quinby, 165 Broadway, New York.

The Antimony & Compounds Company of America has been incorporated in New Jersey with $200,000 capital. The company formerly operated in Belgium. The office of the company will be in the town of Piscataway, Middlesex County, and the incorporators are: Joseph Dhavernas and Eric Goodwin, both of New Brunswick, and Robert Louis Hoguet of New York. Chemicals will be manufactured.

Barnett - Burgess Chemical Company, Hackensack, N. J. Capital, $100,000. Incorporated to buy, sell, extract and deal in alum, sodium, silicon and metals, by C. A. Cote, Hackensack, N. J.; Robert A. Van Voorhiss, Jersey City, and Arthur R. Oakley, Pearl River.

Bowditch Dye Works, of Putnam, Conn., incorporated with $50,000 capital by Detxer Elliott, George A. Vaughn of Thompson, Benjamin Linesey, Jr., of Waukegan, and Fred Ashton of Putnam.

Bradford National Oil & Gas Co., Bradford, Pa., has been incorporated with a capital of $125,000 to produce, refine and prepare for market petroleum, coal, natural gas, etc. Incorporators are S. J. Williams, F. H. Wright, Bradford, Pa.; A. B. Magee, Dover, Del.

The Bridgeport Iron & Metal Co., Bridgeport, Conn., has been incorporated with a capital of $10,000. Incorporators are William and Aaron Olderman of Ansonia, and C. Nowits of Bridgeport.

The Brompton Pulp & Paper Company, Ltd., incorporated in Canada with $9,000,000 capital. Headquarters, Montreal.

The Bryant Paper Company of Kalamazoo, Mich., and the Oxford Paper Company of Rumford Falls, Me., have purchased the Edward Hartington Pulp & Paper Company of St. Johns, N. B., for $3,000,000. A new company was organized to be known as the Nashwaak Pulp & Paper Company and will have offices in New York. Improvements on the mill property, costing $250,000, will be made immediately, insuring a capacity of 120 tons daily of sulphite pulp. The officers are P. J. Chisholm, president; L. M. Bickford, vice-president; F. E. Tufts, treasurer; L. H. Drummond, secretary, all of Brunswick. F. P. Milham and W. B. Milham of Kalamazoo are heavy stockholders and directors.

The Butterworth-Judson Corporation has had a remarkable year, as evidenced by a letter issued by Chandler Bros. & Co., New York and Philadelphia, bankers. The company has plants in Newark, Boston and Baltimore, and it is estimated that for the first ten months of this year the corporation earned $3,600,000. September earnings were almost $580,000 while in October the figures exceeded $670,000. The ratio of increase became very great this fall because of the construction of new plants begun in the late summer. The letter has the following to say in regard to the Butterworth-Judson products: "It is not only manufacturing dyes, but it is producing large quantities of high-grade acids on war orders. To its ordinary chemical production, including the manufacture of aniline dyes, it has added muriatic acid, carbolic acid crystals, sulphuric acids and picric acid. The company's output of picric, carbolic, sulphuric, nitric and mixed acids is used mainly in the manufacture of explosives. The demand for the company's output of acids for explosives has greatly curtailed the time which it has been able to devote to the development and production of dyes. But the company's plants, both its main factories in New Jersey and the new factories which have been constructed in Boston and Baltimore, have been carefully equipped so that on short notice they might be readily converted to the manufacture of dyes, when the abnormal demand for acids stops.

The Central American Oil Co., Dover, Del., capital $5,000,000, is incorporated to acquire and develop oil lands by Geo. W. Dillman, F. D. Buck and K. E. Longfield, of Wilmington.

Chamberlain-Haber Chemical Co., Cleveland, Ohio; capital, $50,000. Incorporators: Charles M. Swingle, Henry W. Haber.

Citizens Oil & Gas Company, Wilmington, Del. Capital, $150,000. Incorporated to refine and market crude oil, petroleum, etc., by Herbert E. Latter, Norman P. Coffin and Clement M. Egner.

Collosus Copper Co., Dover, Del., has been incorporated with a capital of $3,000,000 to mine for gold, silver, lead, zinc, etc. The incorporators are F. R. Hansell, George H. B. Martin, S. C. Seymour, of Philadelphia, Pa.

Colorado Pure Lead Corporation, New York, has been incorporated with a capital of $115,000 to manufacture drugs, acids, alkalies, tinctures, extracts, etc. Incorporators are H. Alexander, L. M. Woodworth, J. L. Rawlinson, 40 Wall Street.

Conservation Oil & Gas Co., Parkersburg, W. Va., has been incorporated with a capital of $25,000. Incorporators are C. S. Shepherd, Laura E. Shepherd, Emily D. Bukey, Estelle M. D. O'Blenness.

Coyote Mining Company, Northport, Wash. Capital, $250,000. Incorporators: J. E. Herron, L. W. Cook and George Osterhout.

Cuban Oil & Gas Co., Tulsa, Okla., has been incorporated with a capital of $25,000. Incorporators are R. M. Kincaid, W. C. Wolfe, R. J. Conneway.

The Cuban Sugar Mill Corporation is being organized at St. Paul, Minn., with a capital stock of $5,100,000.

The Doerr Glass Company, Vineland, N. J., has been incorporated to manufacture and deal in glass. Capital, $50,000. Incorporators: Herman R. Doerr, Francis Doerr and Albert J. Doerr.

Eklowa Oil & Gas Company, Bristow, Okla., is incorporated with a capital stock of $50,000. The incorporators are Henry Lowenstein, Conrad F. Ekfelt, St. Louis, Mo., and Sam K. Wasaff, Bristow.

The Elmstrom Leather Company, Boston, Mass., has been incorporated with $25,000 by Robert Elmstrom, Elmer L. Elmstrom and Hilda E. Johnson.

The Eureka Crucible Flake Graphite Company, Inc., of Saratoga Springs, has been chartered in New York State to carry on a general mining business. Directors: Emmitt T. Lee, Frank W. Lee and Will H. Smith of Saratoga Springs.

The Famol Company, Washington, D. C., has been incorporated with a capital of $35,000 to manufacture chemical preparations of all kinds. The incorporators are W. G. Mertz, F. L. Pickham, F. Vansant, all of Washington.

Feldman - Blair Petroleum Company, Dallas, Tex., have filed an amendment to have their name changed to the National Oil & Refining Company.

Fritz Oil & Gas Co., Zanesville, Ohio, is incorporated with a capital of $20,000. The incorporators are H. O. Burkhart, W. L. Swingle, J. L. Swingle, H. E. Buker and Frederick S. Baron.

General Synthetic Co., 234 Lincoln Avenue, Newark, N. J., incorporated with $100,000 capital to manufacture chemicals.

Globe Refining Company, Houston, Tex., capital $10,000, is incorporated by R. L. Blaffer, W. S. Farish and S. B. Farish.

Graphite Milling Company, Birmingham, Ala., capital $100,000, with $75,000 paid in. Incorporators: Roswell H. Cobb, Ray M. Sterne, E. L. Muchmore. The company is understood to have in mind the operation of graphite mills.

Guernsey County Oil Producing Company, Cleveland, Ohio, incorporated with $100,000 by M. A. Davidson, J. E. Mathews, G. H. Knippenberg, Maurice Masche and H. O. Evans.

The Gunderson Mining Company, with its principal place of business at Deerwood, has been incorporated by C. C. Adams, president and treasurer; Cuyler Adams and R. M. Adams, secretary, all of Deerwood, D. R. Cotton and A. H. Warren, Jr., vice president, both of St. Paul. The capital stock is $50,000.

The J. Frank Hays Company, Camden, N. J., has been incorporated with a capital of $25,000 to manufacture leather. The incorporators are F. R. Hansell, J. A. McPeak, I. C. Clow.

The Hay Creek Oil Company, Santa Anna, Tex., capital $20,000, is incorporated by Jason Tyson, John Campbell, S. J. Pieralt, and others.

The Holland Furnace Company, Holland, Mich., will increase its capital stock from $250,000 to $650,000.

Hoyt-Davis Oil Company, Houston, Tex., is incorporated with $200,000 by G. H. Davis, L. C. Abell, W. W. Parker and J. M. Brown, all of Houston.

The Imperial Chemical Co., Grand Rapids, Mich., has been incorporated with a capital of $100,000 to manufacture all kinds of spraying material and disinfectants. The incorporators are W. Ioor, C. R. Slight, J. D. Cass, D. C. Scribner, F. J. Picket, of Grand Rapids.

Intermediate Chemical Corporation, New York, has been incorporated with a capital of $51,000. Incorporators are M. Reed, A. C. Burrage, Jr., H. Lawson, 497 Dean Street, Brooklyn.

Interstate Tanning Company, Boston, Mass., is incorporated with a capital of $300,000, 12,000 shares at $25 each. The directors are E. C. Fischer, president; Alexander E. Rose, Roxbury, treasurer, and Alfred Karp.

Industrial corporations and domestic railroads have borrowed $2,073,719,900 since Jan. 1, according to figures compiled by the *Journal of Commerce*. New corporations to manufacture war material, dyes and chemicals, to produce oil and refined oil products, and to build ships, have a combined capitalization of $922,486,000.

The Krebs Pigment & Chemical Company, Newport, Del., has increased its capital from $1,000,000 to $2,000,000.

Labelle Oil & Gas Company, Tulsa, Okla., has been incorporated with a capital of $10,000. Incorporators are Dr. J. J. McKanna, Dr. D. W. Conger, W. H. Brown.

The Lackawanna Steel Company's interests at Lebanon, Pa., in the Cornwall ore mines and also the Freeman interests in the Cornwall Railroad, ore mines and furnaces at Cornwall have been purchased by Charles M. Schwab. This gives Mr. Schwab control of the Cornwall ore mines. He will own outright the American Iron & Steel plants, including the $2,000,000 steel mill; the twin Lebanon furnaces and concentrator plant and the twin Polebrook furnaces, and will direct, under lease, the Twin Bird Coleman furnaces at Cornwall, the North Cornwall furnace, the Cornwall Railroad and the Freeman interests in the Cornwall mines.

Leetsdale Foundry & Manufacturing Company, Wilmington, Del., has been incorporated with a capital of $30,000 to manufacture iron, steel, etc. The incorporators are H. E. Latter, N. P. Coffin, C. M. Egner.

The Liberal Oil & Gas Company, Dallas, Texas, has been incorporated with a capital of $125,000. Incorporators are A. M. White, G. W. Sawyer, J. C. Mahoney.

Los Angeles Glass Co., Los Angeles, Cal., Capital $10,000. Incorporators, John Spring, Kate L. Spring and George W. Averill.

The Met-Oh-Lene Co., Inc., New York, has been incorporated with a capital of $32,500, to manufacture dyes, chemicals, paints, etc. The incorporators are L. Prashker, J. Bikelheimer, H. E. Reid, 165 Audubon Ave.

Middle West Fertilizer Co., Springfield, Ohio, is incorporated with a capital of $100,000. The incorporators are Archibold D. Douglass, Augustus H. Dean, Otto A. Koch, C. H. Leach and James B. Yaw.

Mountain Sulphur and Oil Company, Houston, Texas. Capital $5,000, is incorporated by E. A. Cox, D. E. Teaque, M. C. Hale.

The oil plant of the National Oil Company, formerly leased by the Shell Oil Company at Rodeo, has been purchased by Frank Milliss for $50,000.

Nevin Chemical Company, Wilmington, Del., is incorporated with a capital of $200,000 to manufacture chemicals, drugs, etc. The incorporators are Herbert E. Latter, Norman P. Coffin and Clement M. Egner of Wilmington.

New Healdton Oil Company, Ardmore, Texas, is incorporated with a capital stock of $150,000. The incorporators are Jake L. Hamon, Chicago, Harold Wallace and J. S. Mullen, Ardmore.

Oneta Refining Company, Oneta, Okla., is incorporated with a capital of $50,000. The incorporators are F. D. Misener, Charles F. Bisett and C. G. Gray, Tulsa.

Optimis Manufacturing Company, Portland, Me., has been organized with $150,000

capital to manufacture and deal in varnishes, paints, etc., J. Stewart Hollyday, Dorchester, Mass., is president, Mark A. Reinhard, Dorchester, Mass., is treasurer.

Oxythern Chemical Company, San Francisco, Calif., has been incorporated with a capital of $250,000. Incorporators are W. H. Carr, John Roberts, L. McNealey. The company will deal in alkalies and chemicals.

The Pacific Coast Steel Company stock owned by the D. P. Doak interests is reported to have been purchased by William R. Piggott of Seattle. The deal involved about $1,800,000. The Pacific Coast Steel Company has plants at South San Francisco, Portland and Seattle and with the Piggott foundry and shops in Seattle would hold a prominent place on the Pacific Coast.

The Paragon Refining Company, Toledo, Ohio, has been incorporated with $7,500,000. capital stock over the plant and other property of The Paragon Refining Co. of Ironville. The incorporators are Claude A. Ulsh, W. C. Carr, and Rathbun Fuller. The company will be reorganized. The plant is located on the Maumee River and covers 24 acres. It has a capacity of 45,000 bbls. per month. Improvements and additions are contemplated to bring the capacity up to 60,000 bbls.

Peerless Paint Products, Inc., Bronx, New York, is incorporated with $10,000 capital to do business in paint, oil and varnish. Incorporators: H. M. Kahn, S. Traub, S. E. Rosenstein, 1221 Brook Ave., Bronx.

Redux Oil Company, Tulsa, Okla., capital $50,000 is incorporated by Thomas D. Lyon, H. F. Rambo, L. G. Livesay, of Tulsa.

Reid Creek Mining Company, Seattle, Wash. Capital $750,000. Incorporators: Otto Leindecker, Joseph R. Austin, and A. C. Crookall.

Roane County Oil and Gas Company, Charleston W. Va., has been incorporated with a capital of $3,500,000. Incorporators are L. R. Martin, F. J. Holup, L. T. Sanders, E. C. McHugh and R. T. Rosselizv. The company will develop oil and gas properties in The Roane County district.

Charles M. Schwab has purchased for the Bethlehem Steel Company, the controlling interest in the Lebanon and Reading plants of The American Iron and Steel Manufacturing Co., confirming a report recently circulated that the purchase would be made. The plants included a modern twin bolt and nut plant, car forgings, car and railroad materials plant, and a new electrically operated steel mill. The purchase is said to involve over $5,000,000.

Seamons Oil Co., capital $1,000,000. Incorporated to buy, sell and deal in oil, gas and minerals, by Herbert E. Latter, Norman P. Coffin, and Clement M. Egner, all of Wilmington, Del.

Sefton Manufacturing Corporation, Milbrook, N. Y., has been incorporated with a capital of $3,250,000 to manufacture iron, steel, copper and products. Incorporators are D. Havens, 55 Hanson Pl., S. C. T. Dodd, 1918 Avenue H, Brooklyn, A. E. Moore, 29 Arden St., New York City.

The A. O. Smith Corporation has secured a New York charter. Capital $3,500,000. The company will manufacture steel and iron products. Directors are Louis H. Gunther, Samuel B. Howard and Arthur W. Britton.

Springtown Oil and Gas Co., Ft. Worth, Texas, has been incorporated with a capital of $50,000. Incorporators are Grover Smith, Thomas Presnal and S. T. Speer.

A group of bankers, headed by Cassatt & Co., and Frazier & Co., of Philadelphia, and White, Weld & Co., and Merrill, Lynch & Co., of this city has purchased a large interest in the Superior Steel Company of Carnegie, Pa. A new company will be formed which will have $11,500,000 capital stock. The company manufactures hot and cold rolled strip steel and has a capacity of 115,000 tons per annum.

T-P and C-W Oil and Gas Company, Oklahoma City, Okla., is incorporated with a capital of $4,000. The incorporators are M. H. Teller, L. O. Pruiett, and G. E. Chaffee, Oklahoma City.

The Tidal Oil Company, a New York company is contemplating the purchase of the Constantin Refining Company of West Tulsa at a price said to be $2,500,000. The Constantin Co. has a 5,000 barrel plant.

The Tomboy Gold and Copper Company has been incorporated in Arizona and will have its office at Globe. The company is capitalized at $1,000,000. The incorporators are Pearl Skelton, E. R. Little and J. F. Gerald.

Toronatta Zinc Mining Company, Joplin, Mo. Capital $50,000. Incorporators: W. R. Askwith, Frank L. Cody and W. W. Booth.

Transylvania Tanning Co., Brevard, N. C., has been incorporated with a capital of $250,000. Incorporators are J. S. Silverstein of Brevard, N. O. Dworetzky, A. M. White of Rosman.

Union Coal Tar Products Corp., Del., has been incorporated with a capital of $1,000,000 to manufacture chemicals, crude petroleum coal and tar products. Incorporators are S. A. Anderson, S. B. Howard, L. H. Gunther all of New York.

The United Steel Company, Canton, Ohio, has decreased its capital from $150,000 to $15,000.

The Utah Paraffin Oil & Wax Company has been incorporated in Utah with $10,000 capital to mine and treat ores and metals, oil shale and its by-products. Whether the company will develop the paraffine oil deposits on the west shore of Great Salt Lake or make lamp black from the crude oil and gas wells in Wyoming is uncertain. Salt Lake business men are interested.

Officers of the company are Lawrence Greene, president; W. R. Wallace, vice president; James Ingebretsen, secretary-treasurer; M. R. Evans, F. S. Murphy, M. A. Kyser and O. W. Ewing, with the officers constitute the board of directors.

The Virginia-Carolina Chemical Company has become one of the largest stockholders of the American Cyanamid company as the result of the sale to the latter of the phosphate rock mines of the Amalgamated Phosphate Company in Florida, in which Virginia-Carolina Chemical had a large interest.

Weiss Drug Co., Inc., capital $16,000. Incorporated by S. Strauss, A. Weiss and N. C. Weiss. To do business in drugs, medicines, paints and chemicals, 546 W. 147th St.

White Star Refining Co., Oklahoma City, Okla., has been incorporated with a capital of $250,000. Incorporators are M. Campbell, L. Paddock, J. B. Enfield.

The Wisconsin Process Company, Milwaukee, Wis., organized to manufacture and sell chemicals. Capital, $10,000. Incorporators, A. A. Stettem, L. E. Fichaux and others.

Construction and Operation

Arizona

PRESCOTT.—Engineers and officers of the Anglo-Saxon Smelting & Refining Company were expected in New York from London, England, on Dec. 25, from where they were to go to Prescott with the intention of erecting a large custom smelter. The company is reported to be prepared to spend $3,000,000. The party consists of G. G. Lemons, Robert L. Service, secretary of the company; Hugh Rose Croup, president, and two metallurgists.

Arkansas

FORT SMITH.—The Athletic Smelter & Mining Company of Joplin, Mo., is erecting a $125,000 smelter at South Fort Smith. The Business Men's Club has paid $4,600 for the 40-acre site and railroad right of way for the company.

California

KENNETT.—The $400,000 electrolytic-zinc plant of the Mammoth Copper Company is nearing completion at Kennett, and is expected to be ready for service early in February. The plant is the most complete of its kind in the world.

LOS ANGELES.—Baker Iron Works plan erecting steel and corrugated iron, 100 x 300-ft. addition, equipped with two 25-ton electrically driven traveling cranes, to its plant on North Broadway and Castelar Street; cost, about $65,000.

SANTA ROSA.—The North of Bay Counties Press Association has been considering the erection of a co-operative paper mill. Homer W. Wood of Petaluma is president of the association.

VERNON. — The California Chemical Company has prepared plans for a plant 158 x 135 ft., here.

Colorado

GEORGETOWN.—The Colorado Central Mining Company, Edward S. Wiard, general manager, is in the market for supplies for mine, mill, lumbering, and railroad construction. They are desirous of receiving catalogs from concerns who can furnish these materials.

STERLING.—An organization known as the Iliff Promotion Company, made up largely of land holders in the territory east of Sterling, is planning to interview the Great Western Sugar Company of Denver, in regard to the erection of a beet sugar plant at Iliff. H. B. Davis is president of the Promotion Company.

Connecticut

BRIDGEPORT.—The American Tube & Stamping Company has plans for the erection of an additional billet mill and a large rolling mill on its property near here, between Yellow Pond, Stratford and Seaview Avenues. The additions will double the present capacity.

Delaware

WILMINGTON.—The Wilmington Leather Company will erect a six-story factory at Second Street and Greenhill Avenue, to cost about $60,000.

WILMINGTON.—The Wilmington Steel Company, a branch of the Midvale Steel Company, will build several new furnaces as soon as homes can be furnished for 1500 additional workmen.

District of Columbia

WASHINGTON.—According to the annual report of Secretary of the Navy Daniels, the Government plant at Indian Head is producing powder at the rate of 6,000,000 lb. a year, or double the output of three years ago. The sulphuric and nitric acid plants have been enlarged sufficiently to take care of the entire needs of the powder factory, thus effecting a considerable saving in this direction. The cost of the powder has been reduced from 80 to 34c. per lb.

Illinois

QUINCY.—The Monroe Color & Chemical Company has begun operations on its new plant here and will manufacture direct black. The company is an outgrowth of the Monroe Drug Company of Quincy, which manufactures Putnam Fadeless Dyes, and whose operations have been seriously handicapped by the war. Much of the product of the new plant will be used in the Monroe Drug Company's plant. The factory comprises six buildings and the following intermediates will be made: Benzidine, metaphenylenediamine, aniline and H-acid. The plant is complete in every respect and the processes have been carefully worked out. E. N. Monroe is head of both the Monroe Drug Company and the Monroe Color & Chemical Company, and his son, Neal Monroe and Earl Cummins, have perfected the processes and are in charge of the plant, the latter in the capacity of chief chemist.

Indiana

EVANSVILLE.—The Graham Glass Company has announced that it will erect an addition that will double the capacity of its plant and bring the investment up to $1,000,000. The company recently became part of the Owens Bottle Machine Company of Toledo, Ohio.

Kansas

KANSAS CITY.—The million-dollar oil refinery and car repair shops to be erected by the Sinclair Oil Corporation will be located in Kansas City, Kan. Work will be rushed on the plant in order to complete it next spring. The pipe line being erected by the company from the Eldorado, Kan., and Cushing, Okla., oil fields to Kansas City and Chicago will reach Kansas City by that time.

Kentucky

LOUISVILLE.—The Standard Oil Company of Kentucky will erect a refinery with a capacity of 100,000 bbl. per year on a tract of 336 acres recently acquired.

Louisiana

NEW ORLEANS.—The Freeport Mexican Fuel Oil Company plans improvements in the St. Bernard Parish, costing several hundred thousand dollars. W. C. Averill, Jr., is directing the improvements. A large plant will be erected on the Saxonholm property. The company receives its crude oil from Tampico.

Maryland

BALTIMORE.—The Curtis Bay Distilling Company, a subsidiary of the United States Industrial Alcohol Company of New York plans a new plant to handle the by-products from the manufacture of alcohol from molasses. The erection of a mammoth grain elevator to cost $1,000,000 is also planned, on account of the great increase in ocean freight rates. The present plant of the distillery consists of 12 buildings on a tract of 20 acres fronting directly on the deep-water channel of Curtis Bay. The plant was put in operation last summer. The molasses from which the alcohol is made is brought in tank steamers from Cuba.

LONACONING.—The Lonaconing Glass Company will rebuild the plant recently destroyed by fire. Citizens subscribed $29,000 toward the $40,000 that will be raised by issuing 6 per cent preferred stock

Massachusetts

ERVING.—The Erving Paper Mill has recently contracted for the erection of two additions to its plant at Stoneville, near Erving, which will double its capacity. The additions will be completed within one year.

Michigan

DETROIT.—The Pontiac Varnish Company will add two buildings to its plant, thereby doubling its output.

MUSKEGON.—The contract for the erection of the new Brunswick-Balke-Collender Company automobile tire plant, to be constructed within the next sixty days, has been let. The company has already started construction on twenty-four double houses for its workmen.

MUSKEGON.—The Old Montague Iron Works will be rebuilt by a big shipbuilding concern.

Minnesota

ST. PAUL.—Armour & Co., has awarded the contract for driving the piling for foundation of a packing house and subsidiary plants to cost $5,000,000.

Missouri

KANSAS CITY.—H. M. Evans and F. H. Thwing have formed a company called the Evans-Thwing Refining Company, with $1,000,000 capital stock. A site has been purchased in Kansas City for a large refinery, work on which will start at once. This will make the fourth large refinery planned for Kansas City. The Standard Oil Company already has a refinery in operation. The Sinclair Oil Corporation proposes a million dollar plant, and the North American Oil & Refining Company will build a $250,000 plant.

ST. LOUIS.—The Roxana Petroleum Company will build a 10-in. pipe line from Cushing, Okla., to St. Louis, and will erect a $1,000,000 refinery in St. Louis. The Roxana Company is owned by Dutch Shell interests and is a big rival of Standard Oil.

New Jersey

PERTH AMBOY.—A contract has been awarded by the Roessler & Hasslacher Chemical Company for the construction of a $50,000 building.

WOODBRIDGE.—The New Jersey Glue Company will erect an addition to its plant.

New York

ASTORIA, L. I.—The Astoria Light, Heat & Power Company will erect a $50,000 chemical laboratory at Fifteenth Street and Shore Road.

BROOKLYN.—The National Aniline & Chemical Company is building a five-story factory which will cost $100,000 when finished. The company has a factory on Ross Street and the new plant will be an addition to this, being located around the corner. The structure will be used for essential oils.

NEWBURGH.—The Fabrikoid Works plans the erection of a $14,000 addition to its plant here.

Ohio

CINCINNATI.—The Charles Boldt Glass Company has let contracts for the construction of a new paper mill and box factory to cost $350,000. The work will be done by the Ferro Concrete Construction Company.

CLEVELAND.—Reported Carbo-Hydrogen Company, Pittsburgh, will erect factory building at Center and Hemlock Streets; cost, $75,000. Tom Knight, 250 The Arcade, is Cleveland agent.

CLEVELAND.—Reported by C. H. Miller, 2217 Broadview Road, will erect foundry 100 x 260 ft., one story; cost $55,000; at State Road and Cleveland Belt Line Railroad.

CLEVELAND.—Reported Riester & Thesmacher, 1512 West Twenty-fifth Street, will erect sheet metal plant; cost, about $60,000; near State Street Road and Cleveland Belt Line Railroad.

MARIETTA.—The Pioneer Window Glass Company, whose plant will be located in Westview, has been incorporated. The officers are Joseph L. De Brocq, president; Edward H. Knitzer, secretary, and Leon Leitum, treasurer.

YOUNGSTOWN.—The American Sheet & Tinplate Company has awarded the contract to the Sharon Clay Products Company for 800,000 bricks to be used in the construction of ten additional hat mills at the Farrell works. The new mills are expected to be completed by next August.

YOUNGSTOWN.—The Republic Iron & Steel Company plans extensive improvements during the next two or three years, including three additional open-hearth furnaces and an addition to the by-product coke plant.

Oregon

ASTORIA.—The Northern Pacific Brewing plant recently taken by Bruce O. Rowan and J. H. Keating will be remodeled and equipped for condensed milk plant; cost $100,000.

Pennsylvania

BRISTOL.—Rahn & Haas, of Chicago, will build a chemical plant on the Schaffer farm near Bristol. This will make the second new plant for which Bristol has been selected as a location during the last few months. The other is a dye plant to be erected by Daniel Walters.

CARLISLE.—The Mount Holly Paper Mills has been purchased by a Boston concern and will be started up again after being idle for several years. The plant will be enlarged.

JOHNSTOWN.—Directors of the Midvale Steel Company have approved the construction of two blast furnaces at the Cambria Steel Company plant here.

KITTANNING.—The plant of the Kittanning Plate Glass Company, valued at $1,000,000, has been purchased from the trustees by Valentine Neuvert of Kittanning for $82,000. It is reported that the plant will be renovated and operated to capacity.

PITTSBURGH.—The Western Chemical Company, capitalized at $25,000, which has been manufacturing dyes in Cleveland for two months will erect a large factory in Pittsburgh. The officers of the company are George H. Fleming, president; P. J. Maloney, vice-president, and P. S. Summers, secretary and treasurer. The Cleveland address is 1711 Crawford Road, N. E.

READING.—The Carpenter Steel Works has let the contract for a six-story storage house to cost $100,000.

SCRANTON.—Wilson & Co., meat packers, will erect $250,000 storage, manufacturing and distributing plant at Mifflin Avenue and Spruce Street. W. J. Cawley, manager, 7 Dockash Place.

TARENTUM.—The West Penn Steel Company will erect an 80 x 100-ft. addition to its open-hearth department, increasing the capacity of the plant 25 per cent. The company now has four furnaces in operation.

Tennessee

CHATTANOOGA.—The new Chattanooga plant of the Kalbperry Corporation is having its boiler house equipped with Webster Manufacturing Company conveying and elevating machinery.

Texas

HOUSTON.—A company has been formed with headquarters in the Kress Building, Houston, Tex., called the Tidewater Sulphur & Manufacturing Company, to exploit a process for mining sulphur with compressed air. The company owns a tract of 115 acres on Galveston Bay on the Houston Ship Channel, 25 miles from Houston. They claim to have at a depth of 900 ft. a solid bed of sulphur 80 ft. thick. It is proposed to obtain this sulphur by using hot compressed air, under 125 lb. pressure. The compressors are to be run with crude oil, using the exhaust to assist in heating the air, for which purpose the compressed air is passed through two heaters utilizing the exhaust gases from the engines and also being equipped with crude oil burners. It is claimed that the air can be heated to 900 deg. Fahr., but a temperature of 250 deg. Fahr. will probably suffice. After leaving the second heater the air passes down into the vein of sulphur through a pipe, inside of which is another pipe. The heated air melts the sulphur and the molten sulphur is drawn up through the inside pipe by a pump and passes into a vat. Work will be commenced on a plant in three or four months, some of the equipment having already been ordered. It is claimed that the system is cheaper than where steam is used and there is no condensate to bother with. A small plant has been constructed using only 250 ft. of pipe in the air-heating coils and is at present in operation by the Producers Oil Company, of Naborton, La., and is used by them to clean out one of their oil wells. Their former method of cleaning by steam caused a great deal of water to be mixed with the oil. The officers of the company, which is capitalized at $400,000, are W. R. Britton, president; H. P. Rhodes, vice-president; J. C. Tolman, secretary, and DeWitt C. Dunn, treasurer.

MATAGORDA.—Preparations for the opening of the sulphur field at Big Hill are understood to be nearly completed.

Virginia

PULASKI.—The Pulaski Foundry & Manufacturing Corporation, which recently increased its capital from $25,000 to $50,000 will use this capital in enlarging its works.

Washington

LA GRANDE.—The American Nitrogen Products Company, Securities Building, Seattle, has closed a contract with the Tacoma municipal electric system for energy to operate the first unit of its plant, which it is erecting at La Grande, at a cost of about $500,000. The company filed water rights on a site on the Suak-Suiattle River, 50 miles north of Everett, several years ago, and intended to build its plant there, but pending the decision of the Seattle municipal lighting department as to the advisability of the site for municipal power purposes, decided not to wait until the city of Seattle had waived its claim to the power site.

TACOMA.—Several million dollars worth of improvements are being completed at the Tacoma plant of the American Smelting & Refining Company. They are now building a new refinery, have just completed a new power house and are now building a new brick house and quarters for the men.

SEATTLE.—The American Nitrogen Products Company, capitalized at $750,000 is building a small plant for the fixation of nitrogen from the air. The company proposes ultimately to build a large permanent factory on the Sauk-Suiattle River in Snohomish and Skagit counties. C. F. Graff of Seattle is president of the company and the directors include: Dr. I. Jansen, Dr. A. O. Loe, and C. Nasten.

PORT ANGELES.—An agreement has been made between Whalen Bros. of Mills Creek, B. C., and James Tyson, of San Francisco, president of the Puget Sound Mills & Timber Company of Port Angeles, whereby the latter will furnish raw material to operate a paper plant. The first unit to be erected will produce 60 tons daily; the whole plant ultimately costing $750,000.

West Virginia

FAIRMONT.—West Virginia newspaper publishers have been considering the advisability of establishing a paper mill to supply the newspaper trades in this state. A meeting was held in Fairmont at which committees were appointed to report at a meeting in Parkersburg in January. J. J. Devine of the Telegram at Clarksburg, presided.

Wisconsin

MANITOWOC.—Plans for erection of a large rolling mill in connection with the plant of the Aluminum Goods Manufacturing Company in this city are under consideration, according to President George Vits.

MENASHA.—The Gilbert Paper Company is erecting a large addition to its mill on the South Bank of the Fox River. It will be used for water supply tanks and filters.

Canada

TRAIL, B. C.—The Consolidated Mining & Smelting Company of Canada will increase the capacity of its copper refinery at Trail to 15 tons per day. The company handles its own blister copper as well as that from the British Columbia Copper Company's smelter at Greenwood, B. C.

WELLAND, ONT.—Contract awarded by Canadian Steel Foundries, Ltd., Ontario Road, to Ryan & Gardiner, for erecting brick and steel addition to plant; cost $150,000.

Manufacturers' Notes

GAS SHORTAGE IN OHIO.—Glass plants in Sandusky, Ohio, have established their own gas producing plants and no longer have to depend upon the supply of natural gas. They are now able to operate at all times and have an advantage over other glass making centers where natural gas is depended upon and where there is a shortage.

BAKELITE COMPANY MOVES.—The new address of the General Bakelite Company is No. 2 Rector St. New York City. At the new location larger and better arranged offices materially assist in handling the increasing business.

CHEMICAL PLANTS MUST GET PERMITS.—Chemical plants in The Belleville, N. J., district along the Passaic River were required to obtain permits from the Board of Health to operate owing to the discovery of a section in the sanitary code by the health officers. The Belleville Metal & Chemical Co., The Edison plant at Silver

Lake and Eastwood Chemical Company and several other concerns are affected.

SUBSTITUTE FOR AMYL ACETATE.—A substitute for Amyl Acetate in the manufacture of pyroxlin products has been brought out recently by Albert L. Kraus of the Kraus-Millett Co., of Portsmouth, N. H. The new solvent it is claimed fulfills every necessary requirement of the more expensive amyl.

AMERICAN COMPANIES IN CANADA.—Since the outbreak of the European war about fifty American corporations have established branch plants in Canada, the cost of which is estimated at $15,000,000. Prior to the war there were 450 American companies with branch plants in Canada, and the present plant investment represents $150,000,000. Some of the articles manufactured in Canada by American companies recently located there are as follows:

Railway accessories, overalls, chemicals, silverware and flatware, automobiles, horseshoes, steel goods, patent medicines, spices, soaps, perfumes, glue, beet sugar, pumps, greenhouses, railway signals, fuses, boxes, spreaders, silk gloves, stockings, tires, steel, steel products, canned goods, automobile varnishes, belting, store counters, explosives, pulp and paper, sewing machines, aloxite and other abrasives and electric furnace products, grain and elevator machinery, silk and chamoisette gloves, refined nickel, and cottonseed oil products.

GOVERNMENT NITRATE PLANT.—Congressman Longworth of Cincinnati has introduced a bill in the House repealing the act which authorized the erection of a $20,000,000 Government nitrate plant.

WARREN WEBSTER SELLS AIR CONDITIONING BUSINESS.—Warren Webster & Company of Camden, New Jersey, announces that they have disposed of the business of their air conditioning department, and on and after January 1, 1917, the Webster air conditioning apparatus will be manufactured and exploited by the Braemer Air Conditioning Corporation, Lafayette Building, Philadelphia, Pa.

GAS SHORTAGE AFFECTING PENNSYLVANIA MILLS.—The mills in the Monongahela Valley have been hindered by a shortage in gas and several had to shut down for a time around the first of December, including The Macbeth-Evans Glass Co., The Donora Mills, The United Glass Works and The Pittsburgh Steel Foundry. Officials of gas companies explained that the domestic demand was so great that it was necessary to reduce the supply to mills. The large mills are hurrying work on new fuel systems.

FILTER PRESSES. — The Newport Chemical Works, Inc. of Milwaukee, have placed an order with D. R. Sperry & Co., Batavia, Ill., for nine filter presses of both wood and iron construction, for their new Carrollville, Wis., plant. These presses will be in the manufacture of dyes.

ELEVATING AND CONVEYING SYSTEMS.—The Webster Manufacturing Company of Tiffin, Ohio, are installing a complete elevating and conveying system in the new extension of the Ironton Portland Cement Company, Ironton, Ohio, and a conveying and transmission system at the National Phosphate Fertilizer Company, at Centerville, Tenn., for handling the phosphates.

AUSTRALIAN MARKET FOR CHEMICALS.—Advices have been received from Richmond, Australia that there is a market for calcium, magnesium, sulphur and zinc chloride, compressed chlorine and antimony sulphide in Australia.

DISC CRUSHERS.—Chalmers & Williams, Chicago Heights, Illinois, has recently installed four Symons 48 in. vertical disc crushers. At the Federal Lead Co., Flat River, Mo., two at the Burro Mountain Copper Co., Tyrone, N. M., six at the Chile Exploration Co., Chuquicamata, Chile, and two at the Calumet & Arizona Mining Co.

DIE-CASTING COMPANY ADOPTS PROFIT SHARING.—At a complimentary dinner Dec. 15, tendered to the Doehler Executive Club, which is composed of all the executive heads of the Doehler Die-Casting Co., with factories at Brooklyn, N. Y., Newark, N. J., and Toledo, Ohio; the following announcement was made by Mr. H. H. Doehler, its President and General Manager:

To the employees of the Doehler Die-Casting Co. of Brooklyn, Toledo and Newark.

The Doehler Die-Casting Co. realizes the increasing cost of living. To assist our workers to meet these new conditions and the same time to reward our loyal workers, we offer all our employees the following inducements in the form of an extra participating dividend on their wages.

Beginning January 1, 1917, whenever this company declares the regular dividend on their stock it will also declare a wage dividend amounting to 10 per cent per annum to all employees based on all wages actually received including piece work and overtime. This wage dividend is subject to the following conditions.

1. An employee must be in our employ without interruption for a full year before he can participate in the wage dividend. Upon completion of a full year's employment he automatically becomes a candidate for this wage-dividend. His wage-dividend will be calculated from the date of completing the first year's employment to the date of declaration of dividend.

3. This wage dividend when declared will be applied as follows:

First—Will be paid in full to all employees who have been in our employ for a full period of three years or more.

Second—Two-thirds will be paid to all employees who have been in our employ for a full period of two years and less than three years.

Third—One-third will be paid to all employees who have been in our employ for a full period of one year and less than two.

This wage-dividend will be declared quarterly same as our stock dividend.

It was further announced that beginning Jan. 1, 1917, all employees who have been working on the basis of 50 hours per week, will be put on a basis of 48 hours per week at the same pay, believing as Mr. Doehler said, that 8 hours per day was sufficient for all men who work. This company employs 1,200 men, and has a weekly payroll of approximately $25,000.

New Manufacturers' Publications

"Arc Welding." A booklet prepared by the Arc Welding Machine Co., Inc., 220 West Forty-second St., New York. Describes the company's new system and gives general theory of arc welding.

The Prest-O-Lite Co., Inc., Indianapolis, Ind., has issued an instruction book for lead burning with oxy-acetylene. In the introduction it is stated that the term "lead burning" is somewhat misleading, as the work performed by this process should more correctly be termed lead welding. The term burning has however come into common use. The process is not confined to work in lead but can also be used on tin and other low melting point metals or alloys. The book gives a description of The Prest-O-Lite Outfit and directions for burning sheet lead, storage battery work, joining lead and other pipe, making tees, etc.

Bakelite on the Automobile is the title of an attractive booklet issued by the General Bakelite Co., 2 Rector St., (New address), New York City. The booklet illustrates and describes the various uses of bakelite in automobiles, motor cycles, motor boats and airplanes.

Chicago Pneumatic Tool Company, Chicago, Ill., Bulletin E-45, superseding E-40 and describing Duntley portable electric hoists.

Chicago Pneumatic Tool Company, Chicago, Ill. Bulletin 129 describing hose, hose couplings and hose clamp tools.

Schweitzer & Conrad, Inc., Bulletin 1A, describing S & C extra-high-potential fuses.

Aero Pulverizer Company, 120 Broadway, New York, Bulletin 24, describing the Aero pulverizing fuel. Bulletin 25, discussing the advisability of predrying coal before burning.

Armstrong Cork Company, Pittsburgh, Pa., "Nonpareil Corkboard Insulation for Cold Storage Rooms" and "Fifteen Years on Brine Lines," the latter describing a service test.

The Mine and Smelter Supply Company, Denver, Colo., Bulletin 34, describing the Lindsay oil burning assay furnaces and oil burners for which they are sole agents. The furnaces and burners are manufactured by The Colorado Crucible and Clay Company.

The Mine & Smelter Supply Company, Denver, Colo., Bulletin describing the Heusser analytical and assay balances with multiple weight attachments, and various accessories.

American Blower Company, Detroit, Mich., Bulletin 13, Series 9, superseding No. 345, and describing Type D, and Cyclone Disc Ventilating Fans.

Galvanometers, etc.—Pyrolectric Instrument Company, Trenton, N. J., Circular No. 2, describing galvanometers Ayrton shunts, Pohl commutator and dial resistance decade boxes.

Janney, Steinmetz & Co., Phila, Pa., has issued a bulletin describing "Jasco" seamless wrought steel hollow shapes, extra heavy retinned ware, pots, pans, ink buckets, tanks, etc.

Golden-Anderson Valve Specialty Company, Fulton Bldg., Pittsburgh, Bulletin describing Golden-Anderson automatic valves for protecting steam and water lines.

The Brown Hoisting Machinery Company, Cleveland, Ohio, has just put out an attractive calendar for 1917, showing some interesting photographs of unloading operations with Brown apparatus at various ore and coal docks, and loading operations on railroad cars.

Chicago Pneumatic Tool Company, Chicago, Ill., has issued Bulletin 34-W, describing "Grant" fuel oil engines.

The Electric Machinery Company of Minneapolis, Minn., has issued a pamphlet describing its vertical alternator for use in small and medium sized hydro-electric plants. The alternator is direct connected to a vertical waterwheel shaft eliminating all grass, belt, rope drives, etc. The weight of the waterwheel and the downward thrust, as well as the revolving parts of the generator, are carried on a roller thrust bearing submerged in oil. It is claimed that these alternators are much more efficient than a gear or belt driven machine.

Handbook of Westinghouse Watt-hour Meters, issued by Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Gives the early development of watt hour meters, details of Westinghouse meters, constants and test formulas, use of standards and other important details.

Other New Publications

"Facts About Water Power." Prepared by the executive committee of the Water Power Development Association, Munsey Bldg., Washington, D. C. Gives the available water powers, developed and undeveloped and shows the demand for further development under adequate laws.

"Production of Iron and Steel in Canada in 1915." By John McLeish, chief of the Division of Mineral Resources and Statistics. Published by the Department of Mines of Canada, Ottawa.

"Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1915." By Charles W. Henderson. Geological Survey Report, Washington, D. C.

"Freezing Point of Mercury." By R. M. Wilhelm. Scientific Paper No. 294 of Bureau of Standards. The paper gives results of a determination of the freezing point of mercury using platinum resistance thermometers to measure the temperature.

Failure of Brass 2.—Effect of Corrosion on the Ductility and Strength of Brass. By Paul D. Merica. Technologic Paper No. 83 of Bureau of Standards.

Failure of Brass 3.—Initial Stress Produced by the Burning In of Manganese Bronze. By Paul D. Merica and C. P. Karr. Technologic Paper No. 84 of Bureau of Standards.

Gold, Silver, Copper, Lead and Zinc in Utah in 1915. By V. C. Heikes, Geological Survey Report.

Government Ownership and Regulation.—Bulletin of Merchants Association of New York, opposing government ownership and operation of public utilities and advocating exclusive regulation of all railroads by the Federal government.

Gold, Silver, Copper, Lead and Zinc in Montana in 1915. By C. V. Heikes, U. S. Geological Survey Report. Mineral Resources of the U. S.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1915. By C. V. Heikes. U. S. Geological Survey Report. Mineral Resources of U. S.

Annual Report of The Federal Trade Commission. For the year ending June 30, 1916. Government Printing Office, Washington, D. C.

"Practical Handling of Iowa Clays." By Homer F. Staley and Milton F. Beecher. Bulletin 43 of the Engineering Experiment Station at Iowa State College of Agriculture and Mechanic Arts.

Oil Shale in Northwestern Colorado and Adjacent Areas. By Dean E. Winchester. Geological Survey Bulletin 641-F. Contains information showing that when economic conditions justify it, these Colorado shales can be distilled yielding large quantities of oil and furnishing nitrogenous by-products for fertilizer.

National Tank & Pipe Co., Portland, Oregon, has issued catalog 14, describing with illustrations fir and redwood pipe tanks, crossarms, silos and steam pipe, casing, and other specialties and giving new tables and information on pipe not heretofore published.

The Federal Trade Commission has issued in two volumes a report on co-operation in American Export Trade being the results of investigations made by the Federal Trade Commission.

Vapor Pressure Measurements.—"Vapor Pressures of Various Compounds at Low Temperatures" is the title of Bureau of Mines Technical Paper No. 142. By G. A. Burrell and I. W. Robertson. The paper gives the results of measurements on ethylene, ethane, propane, propylene, butane, acetylene, ammonia, sulphur dioxide and nitrous oxide.

A Study of Oil Engines in Iowa Power Plants. By H. W. Wagner. Bulletin 42 of Engineering experiment station at Iowa State College of Agriculture and Mechanic Arts.

Gold, Silver, Copper, Lead and Zinc in Colorado in 1915. By Charles W. Henderson. Geological Survey Report. Part of Mineral Resources of U. S.